A taxonomic revision of the redfin minnows (Pisces, Cyprinidae) from southern Africa

by

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ABSTRACT

The redfin minnows of southern Africa form a distinctive group of cyprinid species traditionally placed within the genus *Barbus*. The species are distributed within the rivers of the Cape Fold Mountains in South Africa and the Drakensberg and Maluti Mountains in Lesotho. The taxonomic history of the species is reviewed with the conclusion that at least two closely similar species pairs require further taxonomic investigation. A broad based character analysis of all the species is presented and taxonomic conclusions made. The character analysis indicates that two natural groups or monophyletic lineages are present, one of which is sufficiently different from all other *Barbus* species to warrant separate generic status. The genus

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This paper is dedicated to the memory of Dr R. A. Jubb (1905–1987).

Pseudobarbus is defined and redescriptions of all the redfin species are provided. A neotype is selected for *Pseudobarbus burchelli*. Aspects of the conservation of these fishes are discussed.

INTRODUCTION

This study concerns a group of cyprinid minnows, known as "redfins", which are found mainly in the streams and rivers draining the Fold Mountains of the Cape Province in South Africa. A hallmark of all the species is the bright red colour of the fins, which has resulted in the species being considered to comprise a natural (or monophyletic) group (Barnard, 1943 and Jubb, 1965 and 1967).

Barnard (1943) was the first author to recognise that there is a distinct group of redfin minnows in southern Cape freshwaters. Earlier authors, often working only with preserved specimens, did not always detect the red colour of the fins of certain species. Barnard (1943) and Jubb (1965 and 1967) resolved many of the taxonomical problems concerning redfin species. In spite of the progress by these authors some of the species required further taxonomic clarification. Other matters of a systematic nature concerning the redfins depended on the prior resolution of these basic taxonomical problems. The phylogenetic relationships of the species and their biogeography are particularly interesting in view of the remarkably integrated nature of the species as a group and their circumscribed distribution at the extreme south of the continent.

The present study deals with the taxonomy of the redfin minnows. It forms part of a broad systematic study (Skelton, 1980) that includes biogeography (Skelton, 1986), phylogeny (Skelton, in prep. a) and osteology (Skelton, in prep. b). Within the context of the phylogenetic philosophy, the taxonomy depends to a large extent on the interrelationships of the species (Wiley, 1981) and the two should be considered together. In the present case where both the in-group and out-group data baselines are comparatively weak there was a need for a detailed character based taxonomic analysis to precede the phylogenetic analysis. The results of the phylogenetic analysis are nevertheless anticipated and incorporated into the taxonomy.

TAXONOMIC HISTORY

Smith (1841) gave the first description of a redfin species *Barbus (Pseudobarbus) burchelli* noting only that it was to be found in "various rivers of the Cape Colony". An attractive but technically inaccurate illustration accompanied the description and showed clearly the red colour of the fins. Smith (1841) commented that local inhabitants referred to this species as the "rooye vlerk carper".

Castelnau (1861), in describing *Gnathendalia vulnerata*, also noted that local inhabitants used the common name "redfin". The name *Gnathendalia* referred to the Genadendal Mission station on the Riviersonderend (Breë River system) where the specimens were collected. The description was based on three skins, now in the British Museum (Natural History) (BMNH). Shortly thereafter Peters (1864) described *Barbus afer* from three specimens collected by Krebs in the 1820's (ffolliott and Liversidge, 1971) but this species was not recognised as a redfin until Jubb's (1965) study.

Günther (1868) synonomised *G. vulnerata* with *Barbus gobionides* Cuvier and Valenciennes, 1842. Type specimens of *B. gobionides* are not known to exist and Barnard (1943) considered this species to be a *nomen dubium* as the original description was not adequate to define any redfin or other species known at the time. Steindachner (1870) described *Barbus multimaculatus* which Boulenger (1905) placed in synonymy with *B. vulneratus*. Boulenger (1911) used Steindachner's figure of *B. multimaculatus* to illustrate *B. vulneratus*.

Boulenger (1911) also described two species only subsequently recognised as redfins viz., *Barbus burgi* and *Barbus asper*. A number of identification errors made by Boulenger (1911) and repeated by Gilchrist and Thompson (1913–1917) were corrected by Barnard (1943). These included the following: four specimens of *B. burchelli* from Deelfontein are actually *Barbus anoplus* Weber,1897; *B. vulneratus* from the Baakens River are *B. afer*; the illustration of *B. anoplus* (not a redfin species) is of a *B. afer* specimen; the illustration of *B. afer* is of a juvenile *B. burgi*. In consequence of Boulenger's mistakes Gilchrist and Thompson (1913–1917) misidentified certain material and also confused specimens of *B. asper* with *B. anoplus* and thereby considered the latter to be a redfin species.

Smith (1936) described *Barbus senticeps*, a relatively large-scaled species, from the Kromme River to the west of the Gamtoos. Barnard (1938a and b) described a further four redfin species although one, *Oreodaimon quathlambae* (Barnard, 1938a), was not recognised as a redfin until the present study (Skelton, 1974a and 1976). The redfins described by Barnard (1938b) were *Barbus calidus*, *Barbus tenuis* and *Barbus phlegethon*. Barnard's (1943) revision included seven redfin species all from the rivers of the Cape Fold Mountain Belt: *B. calidus* and *B. phlegethon* (Olifants River system); *B. burchelli* (Berg and Eerste River systems); *B. vulneratus* (Breë and adjacent rivers);*B. asper* (Gourits and Gamtoos River systems with a variant form in the coastal rivers between the two systems); *B. tenuis* (Gourits River system); and *B. senticeps* (the Kromme, Baakens and Swartkops Rivers of the eastern Cape).

Jubb (1965) made several nomenclatural changes to the redfins. *Barbus afer* was substituted for *B. senticeps*, *B. burgi* replaced *B. burchelli* and *B. burchelli* replaced *B. vulneratus* which became a junior synonym. The reasons for these changes are given later in the species accounts. A few problems nevertheless remained because certain species were difficult to identify and in some cases identification depended more on the geographical origin of the specimens than anything else. Jubb (1967) also reported an unusual population of *B. calidus* which required taxonomic attention (Skelton, 1974b).

Skelton (1974a) noted that the species *Oreodaimon quathlambae* (Barnard, 1938a) has bright red patches over the basal fin areas and suggested that the species may be related to the redfins of the southern Cape. Further study supported this suggestion (Skelton, 1976) and *O. quathlambae* was therefore included in this taxonomic revision.

STUDY AREA

The redfin minnows are found in the rivers draining the Cape Fold Mountain ranges in the southern and south-western Cape Province of South Africa, as well as streams of the high Drakensberg and Maluti Mountains in Lesotho (Fig. 1).

The Cape Fold Mountains are rugged, prominent features of the landscape (Wellington, 1955 and King, 1963), rising to about 2 000 metres. They date from an early Permian orogeny (Halbich *et al.*, 1983). There are two series of ranges, a north-south belt in the west and a double arc of east-west ranges in the south and south-east. These mountains occur between the Great Escarpment and the coast, an important factor in connection with the drainage patterns. The rivers run along the strike of the valleys but in several places turn abruptly to penetrate the mountains through deep, spectacular gorges.

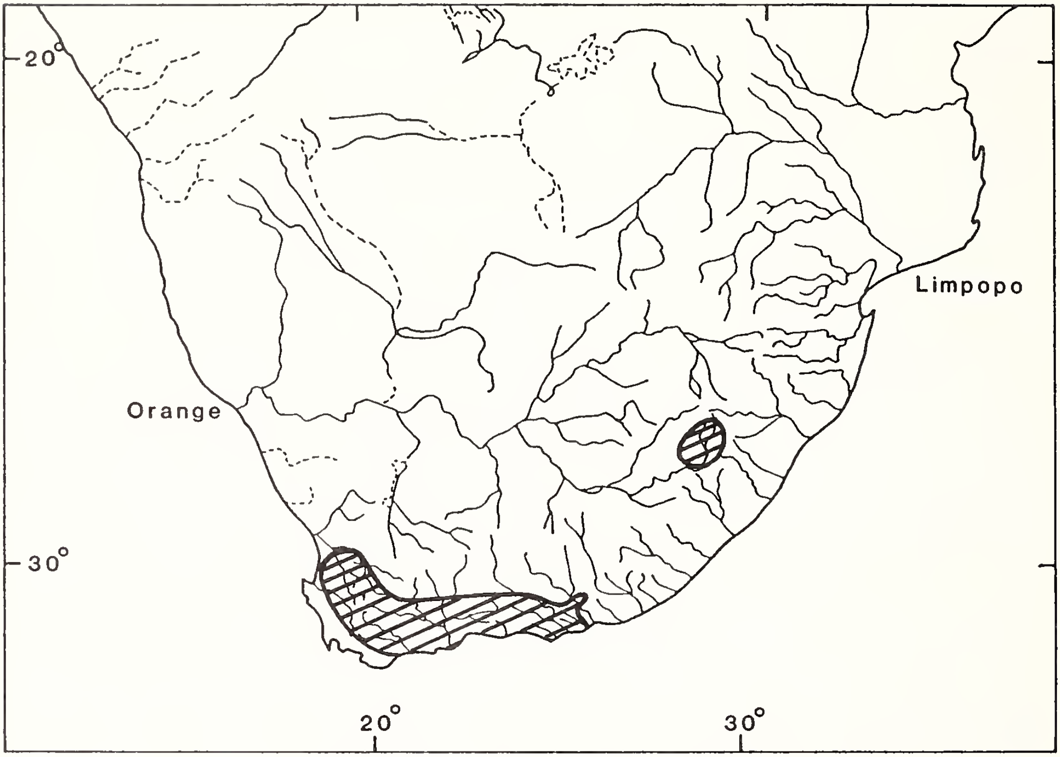

Fig. 1. The general distribution of redfin minnows in southern Africa.

The mountain ranges consist to a great extent of the resistant sandstones of the Table Mountain Group (Cape Supergroup) (Lambrechts, 1979 and Theron, 1983). These are well leached, reworked quartzitic sandstones that impart few soluble salts to the runoff water which is consequently mineral deficient, acidic and often stained brown to a greater or lesser extent (King *et al.*, 1979). The valley formations are mostly of the Bokkeveld Group consisting largely of shales of marine origin that yield waters of high salinity (Bond, 1946).

The drainage of the Fold Mountain region may be conveniently grouped into eight systems or catchment areas. There are four relatively large river systems that drain from the Great Escarpment and penetrate or pass the Fold Mountains to reach the sea. These are, from the west, the (Clanwilliam) Olifants (not to be confused with other rivers of this name in southern Africa), the Gourits, the Gamtoos and the Sundays River systems. Certain rivers adjacent to the Gamtoos and Sundays systems are included with these systems. Other major drainage areas are the west coast which includes the Berg River and adjacent streams, the west Agulhas area in which all the rivers are small and from which no redfin minnows have been recorded, the east Agulhas area including the large Breë River and adjacent streams, and the south coastal area that includes a number of smaller rivers draining the southern flanks of the Outeniqua and Tsitsikama mountain ranges.

The Orange River system arises in the Drakensberg and Maluti Mountains and, as the Vaal sub-system, on the Transvaal and Orange Free State Highveld, to drain westward to the Atlantic Ocean. The Drakensberg Mountains rise to 3 480 m and form an escarpment of extensive sub-horizontal strata of Karoo sediments capped by thick basalts of the "Drakensberg formation" (Truswell, 1977). The source tributaries often arise from seepage bogs that provide clear, slightly acidic waters. Water quality changes rapidly once the streams reach the underlying Beaufort sediments which contribute large quantities of dissolved and suspended matter (Cambray *et al.*, 1986).

MATERIALS AND METHODS

Linear and meristic measurements

Measurements were taken with vernier calipers and recorded to the nearest 0,1 mm. The pharyngeal bones were measured using a calibrated graticule on a binocular stereo microscope. Samples included specimens of both sexes and initially the measurements were analysed separately for each sex and collectively for the sample, if no difference between the sexes was evident. As far as possible only specimens of adult proportions (i.e. > 50 mm SL) were used for the intra- and interspecific analysis. Wherever possible the samples included 30 specimens and at least one sample of each species included a broad size range of specimens to assess allometry.

Linear measurements, as shown in Fig. 2 , were taken according to Hubbs and Lagler (1958) except as follows:

(i) measurements from the anterior end of the head were taken from the anterior symphysis of the retracted premaxillae.

(ii) measurements on the head were taken from the bony margins of the reference points.

(iii) predorsal length was measured along the horizontal to the intersection of the vertical line through the anterior base of the fin.

(iv) pectoral to pelvic length is the median distance between the posterior margins of the bases of the fins.

(v) pelvic to anal length is the median distance between the posterior margin of the pelvic bases and the anterior margin of the anal fin base.

(vi) pharyngeal bones were measured according to Chu (1935) (Fig. 3). The pharyngeal bones were dissected from 10 specimens from each sample, macerated in trypsin solution for a few days and then defleshed with forceps and dried. Pharyngeal teeth were counted in rows and presented in a formula (Eastman and Underhill, 1973) giving the number on the left bone from the minor (outer) row to the major (inner) row followed by the number on the right bone, from the major (inner) to minor (outer) row.

(viii) the length of the gut (intestine) was measured according to the method of Snelson (1971). The tract was severed immediately behind the transverse septum of the body cavity and at the anus. Viscera were detached and the tract straightened and pinned to a board without stretching for measurement to the nearest 1,0 mm.

Measurements are expressed as percentage Standard length (SL) except for the following which are given as percentage head length (HL): head depth, snout length, orbit diameter, postorbit length and interorbit length. Barbels are given as percentage orbit diameter (OD).

Meristic characters are given with the number of individual specimens counted in

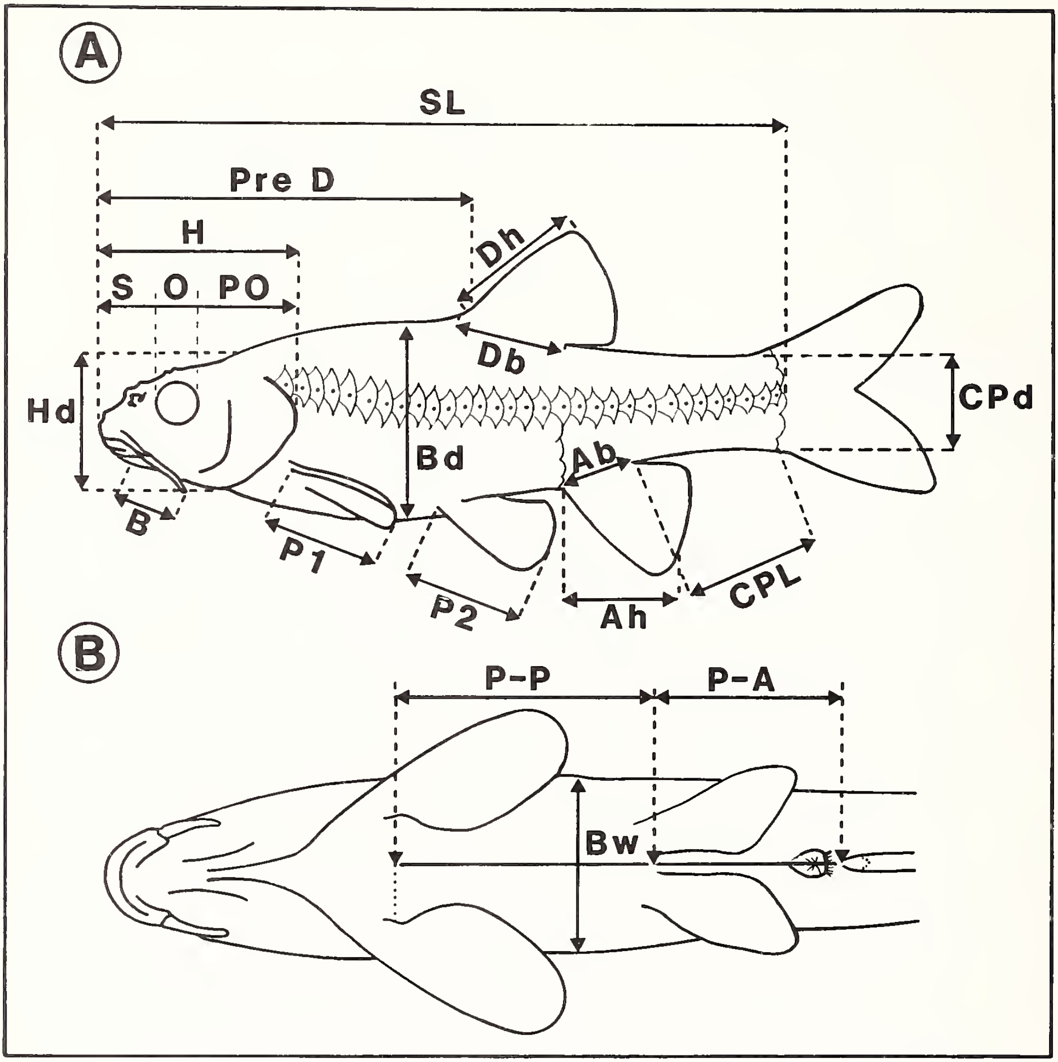

Fig. 2. Linear measurements in this study. Abbreviations : Ab—anal fin base; Ah—anal fin height; B—barbel length; Bd—body depth; Bw—body width; CPd—caudal peduncle depth ; CPL—caudal peduncle length; Db—dorsal fin base; Dh—dorsal fin height; HL—head length; Hd—head depth; O—orbit diameter; P1—pectoral fin length; P2—pelvic fin length; PO—postorbit length; P-A—pelvic to anal fin length; P-P—pectoral to pelvic fin length; PreD—predorsal length; S—snout length; SL—standard length.

parenthesis. Scale and fin ray counts were made as in Hubbs and Lagler (1958) (Fig. 4a) except for the predorsal scale count which was taken as in Snelson (1972). This count records the number of oblique scale rows crossing an imaginary line between the anterior base of the dorsal

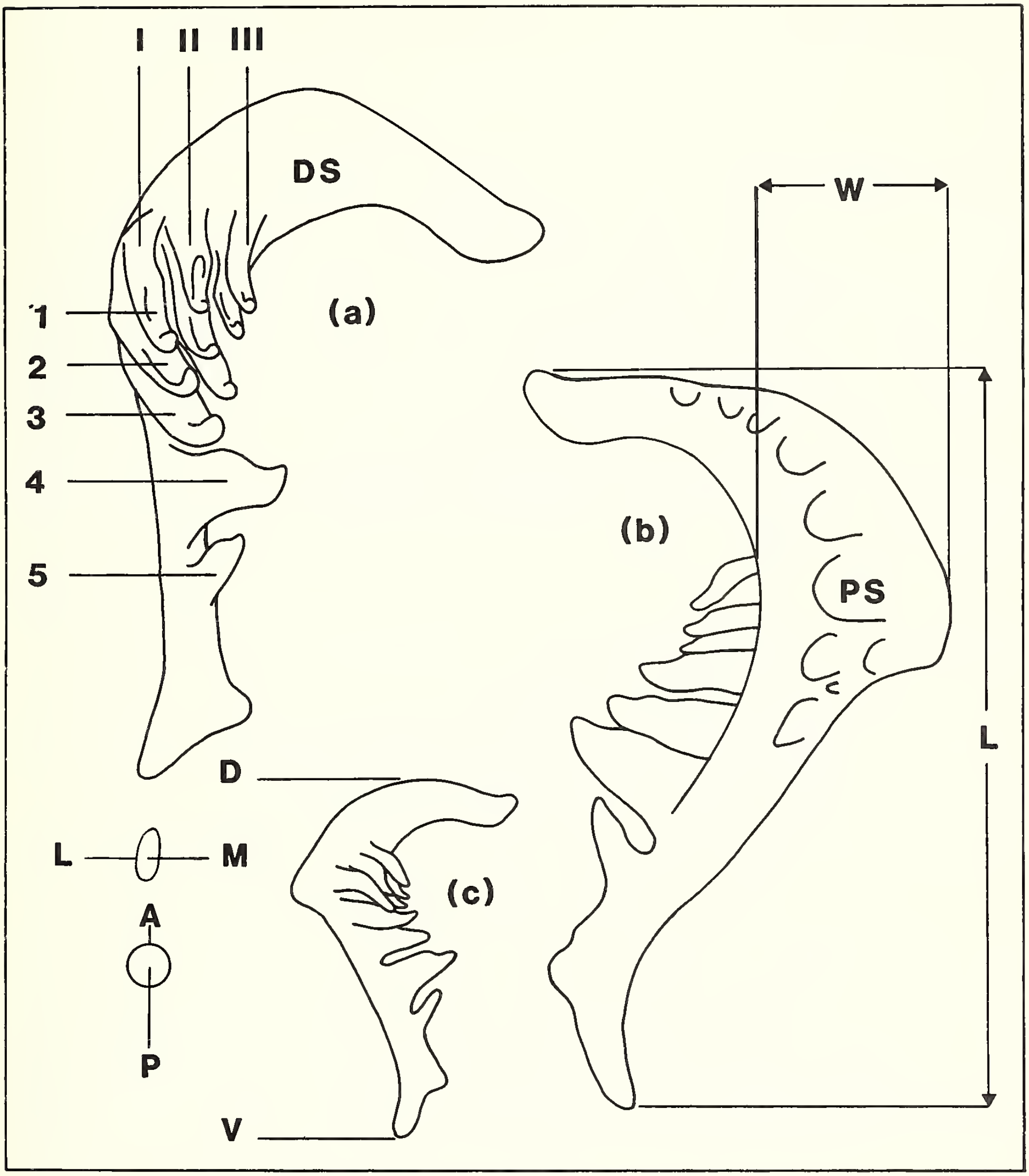

Fig. 3. Measurements and orientation of pharyngeal bones. (a) postero-medial view of the left pharyngeal bone: I—major or inner row, II—middle row, III—minor or outer row. (b) antero-lateral view of left pharyngeal bone : L—length, W—width. (c) orientation : A—anterior, D—dorsal, V—ventral, M—medial, PS—pitted surface, DS—dorsal surface.

fin and the posterior margin of the head at the nape. Single scales interposed between two otherwise regular rows are omitted.

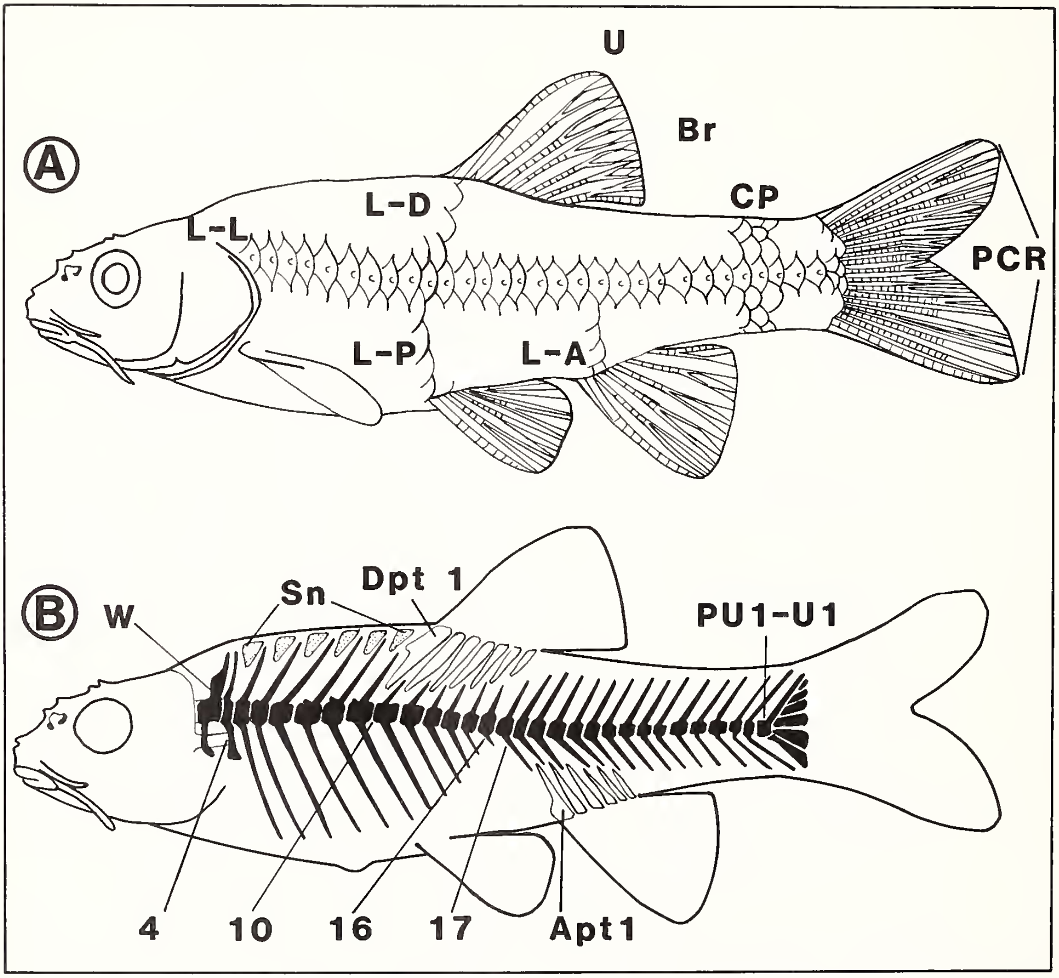

Fig. 4. Meristic measurements as taken in this study. (a) scale and fin ray counts, (b) post-cranial skeletal meristics. Apt1—first anal pterygiophore, Br—branched fin rays, CP—caudal peduncle scale rows, Dpt1—first dorsal fin pterygiophore, L-A—lateral line to anal fin scale rows, L-L—lateral line scales, L-P lateral line to pelvic fin scale rows, PCR—principal caudal fin rays, PU1+U1—compound ural centrum, Sn—supraneural bones, U—unbranched fin rays, W—Weberian vertebrae, 4–4th vertebra, 10—last predorsal vertebra, 16—first caudal vertebra, 17—last preanal vertebra.

Branched and unbranched rays are considered separately in the case of the dorsal and anal fins, but all rays are included in a single count in the case of the pectoral and pelvic fins. Principal caudal rays were counted as branched rays plus a single outer dorsal and ventral unbranched or simple ray.

Postcranial skeletal meristics were taken from radiographs as shown in Fig. 4b. Vertebral counts include the four Weberian vertebrae and a single ural centrum (PU1 + U1). The first caudal vertebra was taken as the first unit with a closed haemal arch as indicated by a bright exposure point on the radiograph (an indication of increased bone density). Vertebrae before the dorsal (predorsal vertebrae) or anal fins (preanal vertebrae) include all vertebrae before or opposite the respective leading pterygiophore. Supraneural bones include all independent bones between the head and the first dorsal pterygiophore.

The number of scale radii is the mean number of radii counted from five scales, each scale taken from one of the following different body regions on the right side: above and below the lateral line in the area before the dorsal fin, and behind the dorsal fin above and below the lateral line. Scales were removed, stained in alizarin red, defleshed and examined under a stereo microscope. Primary radii were considered as radii extending from the focus to or close to the scale margin. Scales with a diffuse focus were excluded from the count.

Osteology

Specimens were cleared with trypsin and stained for bone with alizarin red (Taylor, 1967). The study was completed before the double cartilage-bone staining methods using alcian blue for cartilage were available. Cartilage components were therefore stained with Victoria blue after dissection of a particular skeletal complex.

Phylogenetic analysis

The full results of the phylogenetic analysis are being prepared for separate publication (Skelton, in prep. a). At a generic level the phylogenetic relationships have been incorporated into this paper and the methods employed in the analysis are therefore presented here. Species interrelationships were investigated in accordance with the philosophy of cladistics or phylogenetic systematics (Wiley, 1981). The original phylogenetic methods of Hennig (1950 and 1966) included a number of principles and practices of which all but one have been discarded as a means of determining the phylogenetic relationships between taxa. The valid criterion is that related taxa share at least one relatively derived (homologous) character state (synapomorphy) which is not shared with other taxa. A monophyletic group is considered to be one which includes a common ancestor and all of its descendants (Wiley, 1981).

Character state was determined according to the method of out-group comparison (Wiley, 1981). The operating principle behind the method is given by Wiley (1981) as the 'out-group rule' as follows: given two characters that are homologues and found within a single monophyletic group the character that is also found in the sister group is the plesiomorph (less derived or primitive state) whereas the character found only within the monophyletic group is the apomorphic character. A complementary method of character state evaluation is one using the ontogenetic criterion which is stated by Wiley (1981) as : "given an ontogenetic character sequence which goes from a character found in the outgroup to a character found only within the group considered, the character found only in the group considered is the derived character and the character found in the out-group is primitive."

Abbreviations

Institutional abbreviations follow Leviton *et al.* (1985) and are: AMGP—Albany Museum, Grahamstown (fish collection); BMNH—British Museum (Natural History), London; MRAC

—Musee de l'Afrique Centrale, Tervuren; MNHN—Museum National d'Histoire Naturelle, Paris; NMP—Natal Museum, Pietermaritzburg; RUSI—J. L. B. Smith Institute of Ichthyology, Grahamstown; SAM—South African Museum, Cape Town; TMP—Transvaal Museum, Pretoria.

Character and osteological abbreviations are: Ab—anal fin base; Ah—anal fin length; Apt—anal pterygiophore; B—barbel length; Bd—body depth; Br—branched rays; Bw—body width; CP—caudal peduncle scale rows; CPd–caudal peduncle depth; CPL—caudal peduncle length; Db—dorsal fin base; Dh—dorsal fin height (length); Dpt—dorsal pterygiophore; H—head length; Hd—head depth; L-A—lateral line to anal fin scale rows; L-D—lateral line to dorsal fin scale rows; LL—lateral line scales; L-P—lateral line to pelvic scales; O—orbit diameter; PCR—principal caudal rays; PL—pectoral fin length; P2—pelvic fin length; PO—postorbit length; P-A—pelvic to anal fin length; P-P—pectoral to pelvic fin length; Pre D—predorsal length; Pu1+U1—compound ural vertebral centrum; S—snout length; SL—Standard length; Sn—supraneural bone(s); U—unbranched fin rays; W—Weberian vertebrae (vertebrae 1–4).

MATERIALS

All redfin material used in this study is recorded under the individual species accounts. The samples used for morphometric and meristic measurements are given in Table 1 and their respective localities are shown in Fig. 5.

TABLE 1.

Samples of redfin minnows measured.

Species	Collection No.	Locality No. (Fig. 5)
B. burchelli	AMG/P 1411, 3463	23
	AMG/P 2079	19
	AMG/P 2077	20
	AMG/P 3472	18
	AMG/P 1368	24
	AMG/P 1566	21
	SAM 18731	22
B. burgi	AMG/P 2076, 1578	27
	AMG/P 1874, 1875	28
	SAM 18747	26
	SAM 4695, 5090	25
	BMNH 1901.2.11:14–16	27
	SAM 4696	27
B. phlegethon	SAM 22484	29
	SAM 22749	29
	SAM 22483	29
	AMG/P 722	30
	AMG/P 1394	29
	AMG/P 1852	32

Species	Collection No.	Locality No. (Fig. 5)
	AMG/P 1863	30
	AMG/P 2054	35
B. tenuis	AMG/P 2081, 1935, 608	(not plotted)
	AMG/P 2666	15
	AMG/P 2667	16
	AMG/P 3186	11
B. afer	AMG/P 609	1
	AMG/P 745, 2524	2
	AMG/P 766	3
	AMG/P 2651	8
B. afer (Gamtoos)	AMG/P 1415	4
	AMG/P 1374, 1375	5
	AMG/P 1921	6
B. asper (variant)	AMG/P 2652, 2654	9
	AMG/P 2656	9
	AMG/P 2659	10
	AMG/P 1790	11
	AMG/P 110, 584	11
B. asper	AMG/P 1744	7
	AMG/P 2663	13
	AMG/P 1699	17
	AMG/P 607	14
B. calidus	AMG/P 1871	29
	AMG/P 1862	30
	AMG/P 1797, 1371	31
	AMG/P 1850	32
	AMG/P 1844	33
	AMG/P 1855	34
	AMG/P 1857	34
B. erubescens	AMG/P 1867, 2045, 2049	36
	AMG/P 1866, 2075	36
	AMG/P 2074	36
O. quathlambae	AMG/P 1540, 1877, 1823	37
	AMG/P 3473–3478	37
	AMG/P 3479	38
	AMG/P 3480	39
	SAM 19018	40

Delimitation of taxa for analysis

A preliminary analysis of the results of the morphometric and meristic characters was made according to the individual samples (populations) measured as in Table 1. The species to which these samples were assigned are those established by Jubb (1965 and 1967), Barnard (1938a) and Skelton (1974b). In the case of *Barbus afer* and *B. asper* there was some doubt as to which of the species certain of the samples should be referred. These samples were therefore analysed separately and labelled as *B. asper* (variant) and *B. afer* (Gamtoos). *B. asper* (variant) refers to the populations of redfins found in the coastal streams between the mouth of the Gourits and the

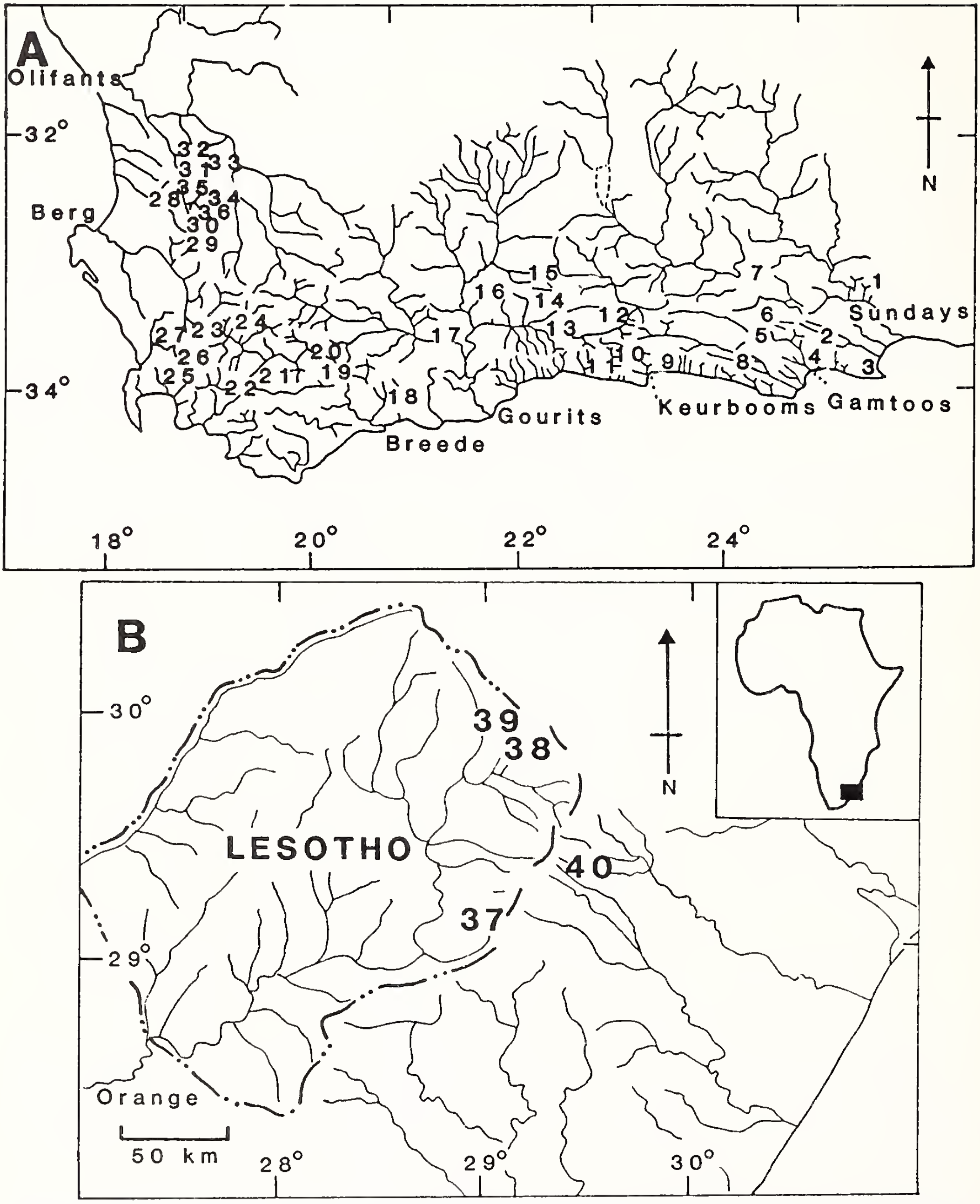

Fig. 5. Localities of samples used for morphometric and meristic analysis (a) south coastal drainages (b) upper Orange and adjacent river drainages. Localities as given in Table 1.

mouth of the Gamtoos except for the Kromme River population which was included in *B. afer* (Jubb, 1965). Populations of redfins from the Fold Mountain tributaries of the Gamtoos River system are those referred to *B. afer* (Gamtoos). Typical *B. asper* also occurs in the Gamtoos River system but this species was found to be restricted to the large Groot River tributary of this system.

As this investigation progressed it became evident that the major character differences lay between *B. calidus* and *B. erubescens* on the one hand, and the remaining species on the other. To facilitate repetitive reference to these groups they are named the "serrated" and "flexible" rayed species respectively (in reference to the nature of their last unbranched dorsal fin ray).

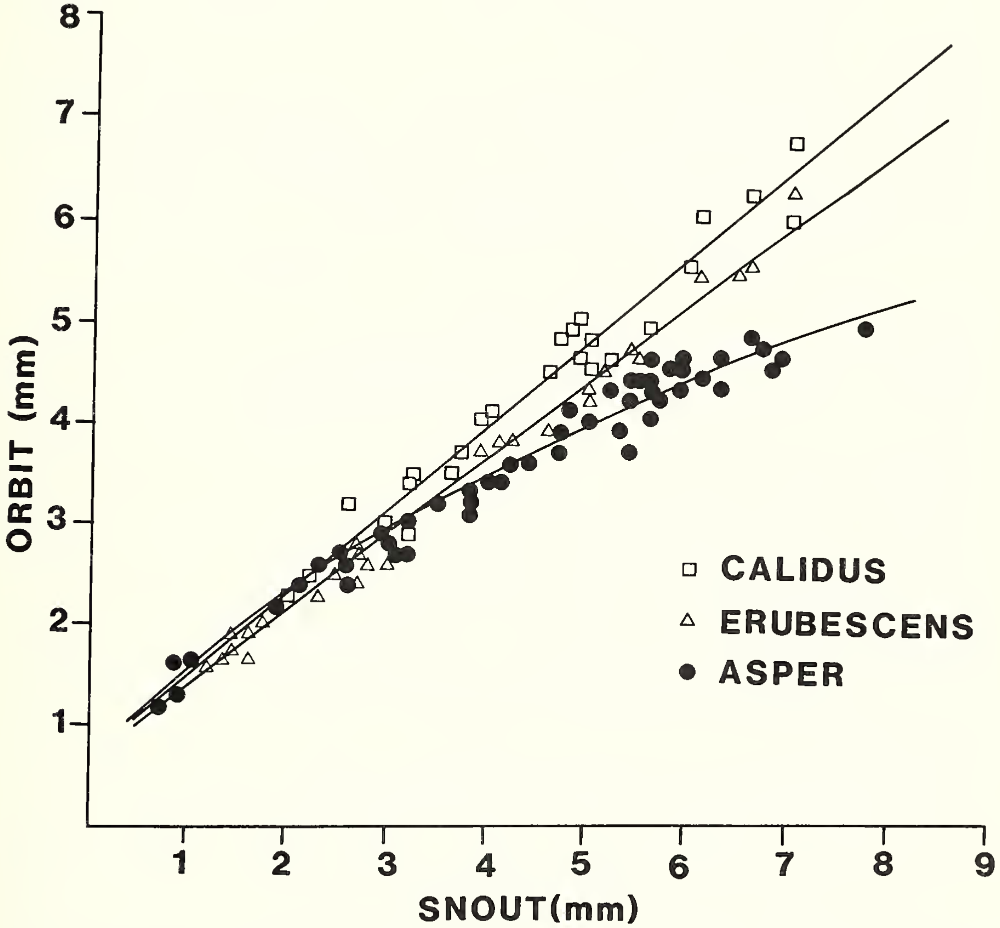

Fig. 6. The relationship between orbit diameter and length of the snout in three redfin minnows *B. asper*, *B. calidus* and *B. erubescens*.

CHARACTER ANALYSIS

Linear measurements

The morphometric measurements for each species are given under the individual descriptive accounts (Tables 14–22). The species are generally similar in form so that many measurements differ only slightly between them and are therefore mainly useful for the purpose of description. Only measurements or proportions which serve to distinguish a species or exhibit noteworthy intraspecific variation will be elaborated on in this section.

The largest redfin specimen examined was a *B. burchelli* of 134 mm SL. Gephard (1978) reports a specimen of *O. quathlambae* of 143 mm total length (TL) which is also about 130 mm SL. The largest specimen of *B. phlegethon* measured 71 mm SL making it the smallest redfin species. The maximum size for the other redfin species lies between 85 mm SL (*B. tenuis*) and 120 mm SL (*B. burgi*).

Of the head proportions the ratio between the snout length and the orbit diameter establishes an interesting difference between the two "serrated" species and the "flexible" species (Fig. 6). In *B. calidus* and *B. erubescens* the plot of orbit diameter against snout length is linear but in the flexible rayed species (e.g. *B. asper* in Fig. 6) a curvilinear function is described and the orbit is relatively smaller in larger specimens.

The depth of the head is least in *O. quathlambae* and *B. tenuis* and both species have a more slender body profile (depth) than other redfins (Fig. 7).

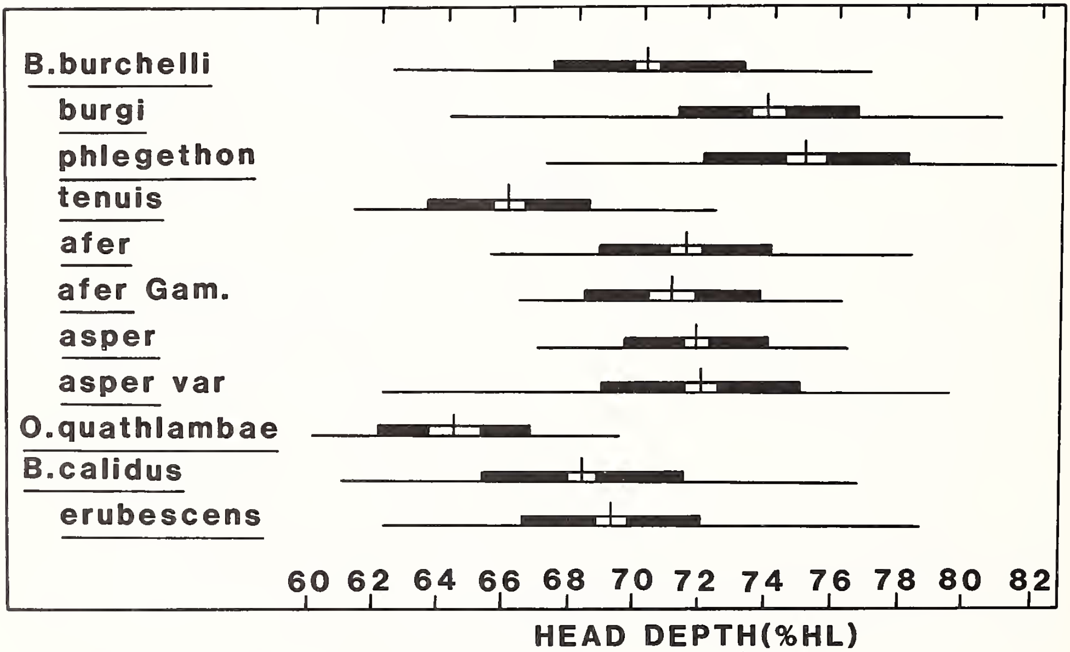

Fig. 7. Head depth (%HL) of redfin minnows.

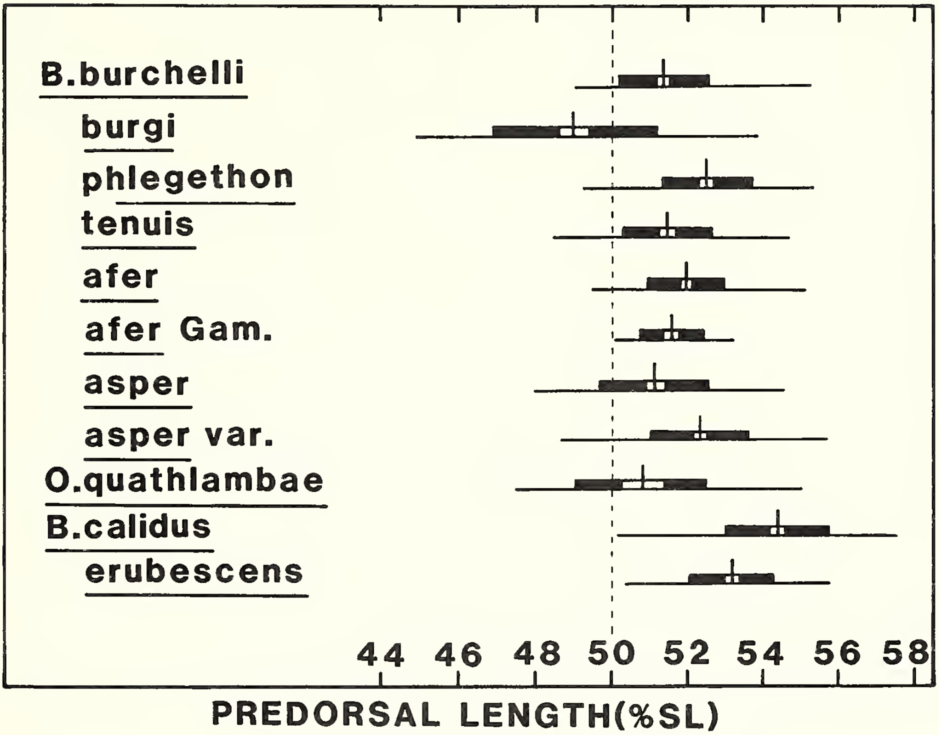

Fig. 8. Predorsal length (%SL) of redfin minnows.

The results of the analysis of the predorsal length include two pertinent taxonomic features *viz*., *B. burgi* has a relatively short predorsal length and *B. calidus* and *B. erubescens* have relatively longer predorsal lengths than the other redfins (Fig. 8). In the case of *B. burgi* there is, however, a considerable amount of intraspecific variation in this character and it is only in the Berg River samples that the predorsal is shorter than in other redfin species. The shorter predorsal length in *B. burgi* correlates with a shorter head length in Berg River specimens (Fig. 9). It appears that this may account for the phenomenon but it is also noted that *B. burgi* has the lowest modal predorsal vertebral count (Table 6) which would also tend to reduce the predorsal length.

A relatively high predorsal vertebral count in *B. calidus* may likewise account for the long predorsal length of the species (Fig. 8 and Table 6D). The origin of the dorsal fin in both *B. calidus* and *B. erubescens* is placed behind the vertical through the origin of the pelvic fins whereas in the other redfin species the dorsal fin origin lies over or only slightly behind the origin of the pelvics.

Barnard (1943) distinguished *B. tenuis* from *B. asper* and *B. afer* on the basis of body depth. Body depth is generally an unreliable cyprinid taxonomic character because it is so easily influenced by the condition of the specimen both in the living and preserved states. In spite of these limitations the redfin species do have fairly characteristic profiles and it is useful to note

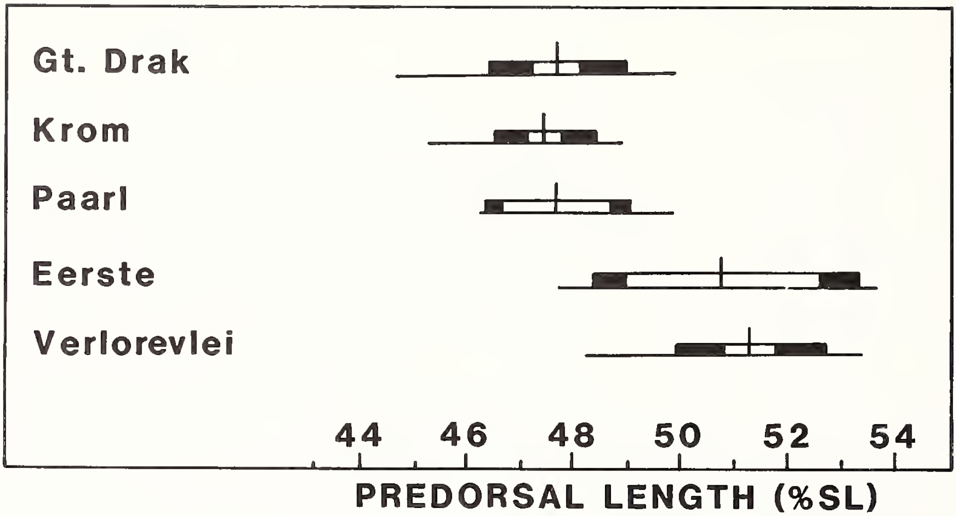

Fig. 9. Intraspecific variation in the predorsal length of *B. burgi*.

that the body depth in these minnows correlates generally with the length of the intestine. The redfins form two fairly distinct groups with regard to body depth, those with a slender profile—*B. tenuis*, *O. quathlambae*, *B. calidus* and *B. erubescens*, and the rest with relatively deep body profiles (Fig. 10). The former species with shallow profiles all have relatively short guts (see below, p. 243) and the deeper bodied forms have longer more involuted intestines.

Some interesting trends are evident in the proportions of the caudal peduncle of redfin species. The peduncle of *B. calidus* and *B. erubescens* is shorter than in the flexible rayed species (Fig. 11). Intraspecific variation in this character is not usually marked but an exception is in *B. asper* where the specimens from the Gamtoos River system have a significantly longer caudal peduncle than those from the Gourits River system (Fig. 12). There is a tendency for the males of flexible rayed redfins to have slightly deeper caudal peduncles than do females (Fig. 13). *B. calidus* has a relatively narrow caudal peduncle, and this is taxonomically useful in comparison with *B. erubescens*.

Barbels are frequently employed as taxonomic characters in cyprinids and although their value is often overestimated (Gilbert and Bailey, 1972, and Schmidt, 1983), when used in the correct context and perspective, they may be extremely useful features. The redfins have either one or two pairs of simple barbels. The posterior pair is characteristic of all the species but an anterior pair is consistently present only in *B. burchelli*, *B. burgi*, *B. calidus* and *B. erubescens* (Fig. 14). Occasionally individual specimens of the other species have one or two anterior barbels. Certain populations of *B. tenuis* have a fairly high incidence of anterior barbels, e.g. 20% of the specimens from the Waterkloof River (Gourits system) had anterior barbels, but 50% of these had only a single anterior barbel.

The anterior barbels of *B. burgi* develop relatively late and are visible in specimens greater than about 45 mm SL (Barnard, 1943). In *B. burchelli* these barbels develop at an earlier stage and are therefore longer than those of similar sized *B. burgi*. Short barbels are characteristic of

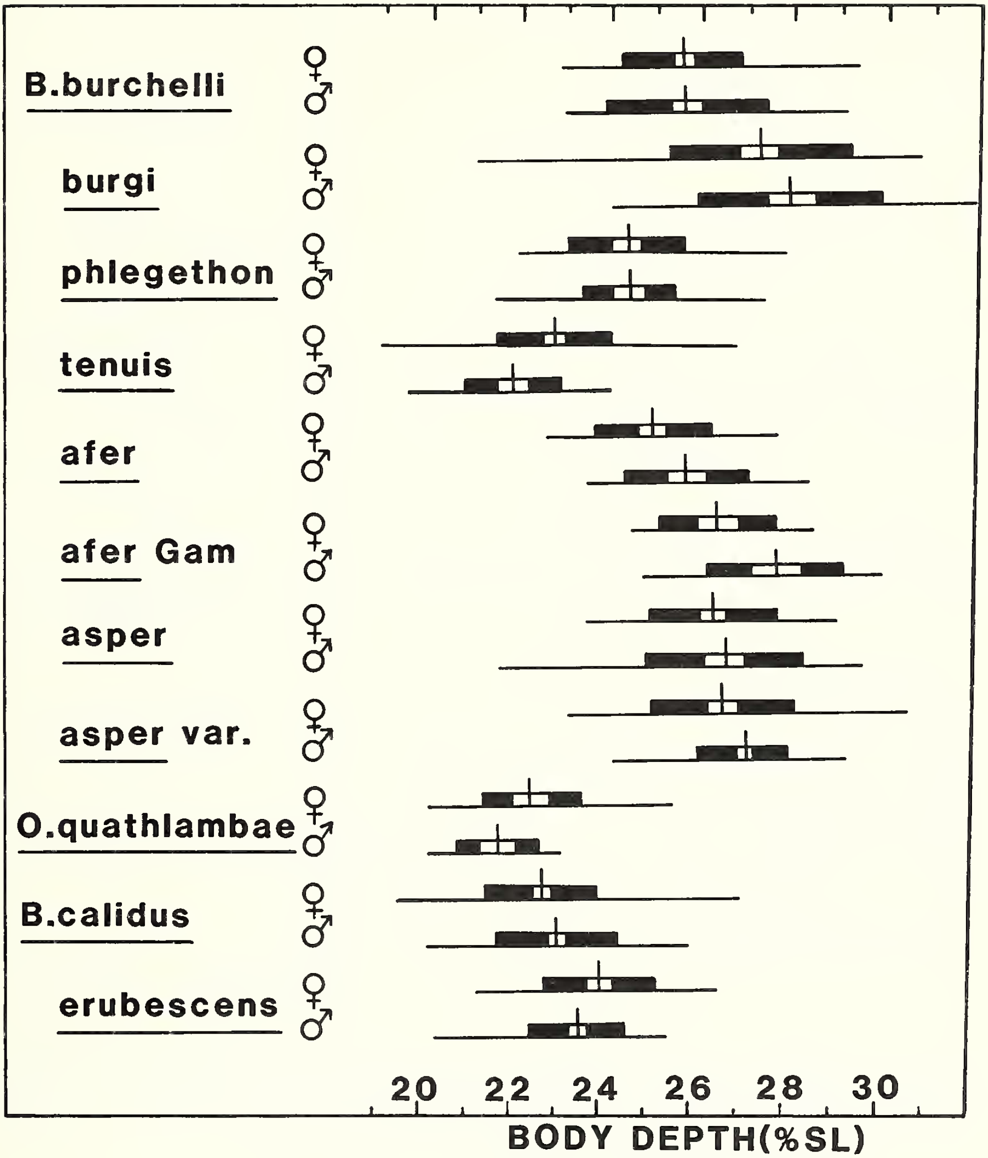

Fig. 10. Body depth (%SL) of redfin minnows.

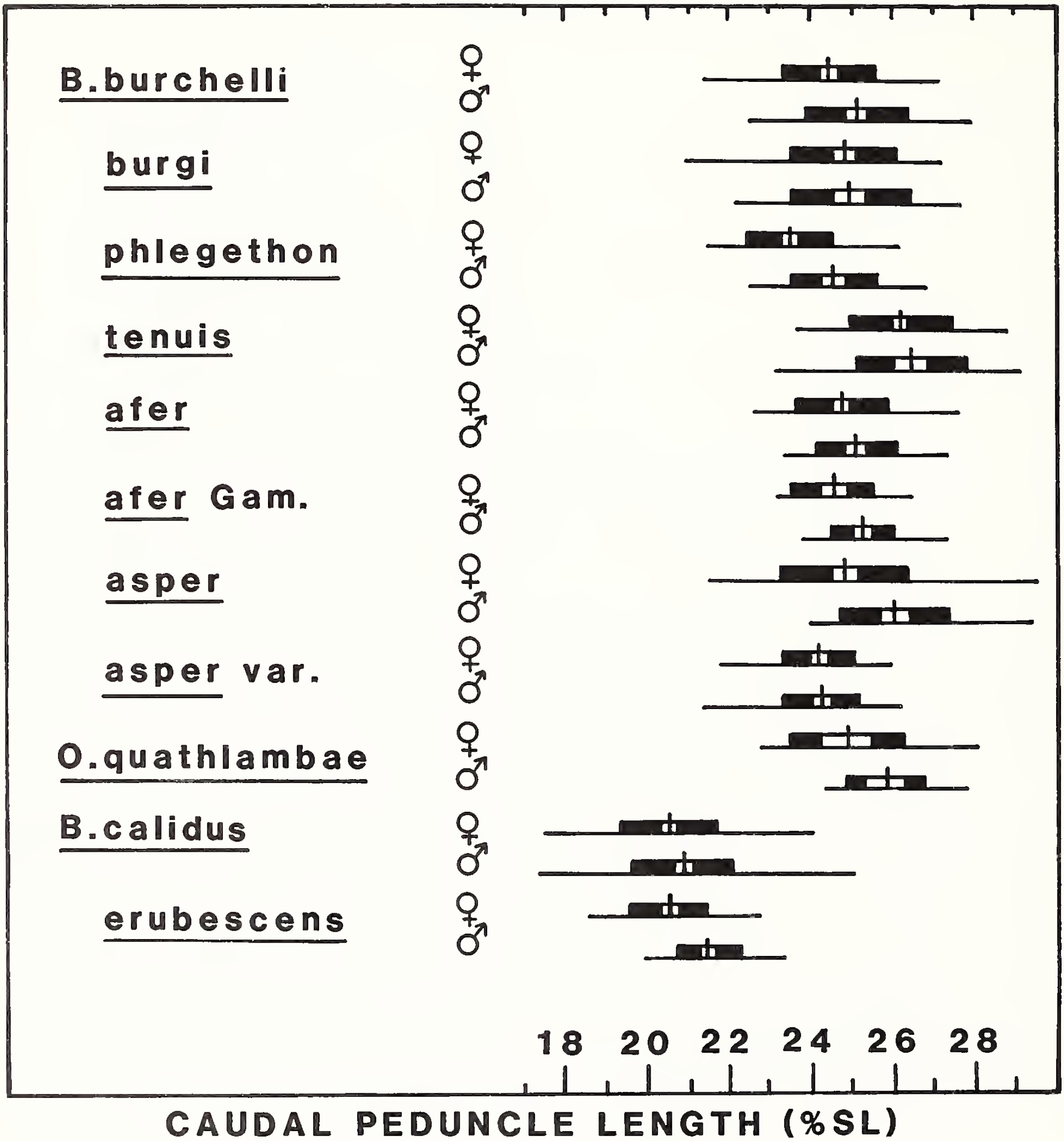

Fig. 11. Caudal peduncle length (%SL) of redfin minnows.

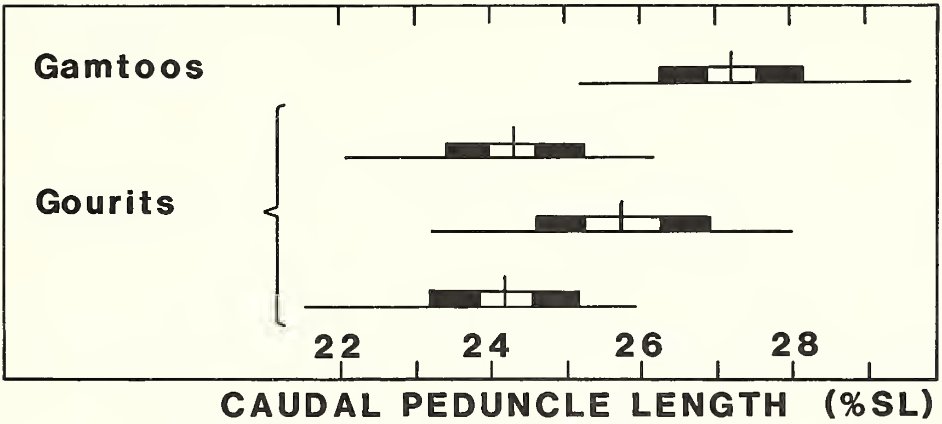

Fig. 12. Caudal peduncle length (%SL) of *B. asper*.

B. phlegethon and *O. quathlambae* (Fig. 14). The actual length of the barbels is subject to considerable intraspecific variation especially in the widespread species such as *B. afer* and *B. asper* (variant) populations.

Fins

The fins of cyprinid fishes are well known to be labile structures with their shape and proportions subject to the environmental and functional demands placed on them (Hubbs, 1940 and Alexander, 1967). There are no outstanding taxonomic differences between the length of the fins of redfin species. Intraspecific differences are in certain cases at least as large as interspecific differences. In *B. tenuis* for example the population from the Keurbooms River system has relatively longer fins than conspecifics in the Gourits River system. The Keurbooms catchment receives a higher mean average rainfall compared to Gourits River catchments (Midgeley and Pitman, 1969). This suggests that flow is likely to be higher on average in the Keurbooms, a factor which favours the development of longer fins (Hubbs, 1940) and may be responsible for the observed differences in this case.

Sexual dimorphism of the fins is clearly evident in most of the flexible-rayed species (Barnard, 1943). Boulenger (1911) indicated that the pectoral fins of *B. asper* males were longer than those of the females. Barnard (1943) qualified this statement of dimorphism by referring to the length of the pectoral relative to the base of the pelvic fins. In males of the flexible-rayed species the pectorals reach the base of the pelvics but in the females the pectorals are short of the pelvics. In the case of juveniles the pectoral fins reach the pelvics (except in *B. phlegethon*).

The length of the pectoral and the pectoral to pelvic distance is shown in Fig. 15. Apart from *B. calidus* and *B. erubescens* the males have relatively longer pectoral fins but shorter distances between the fins than the females. Interspecific differences and differences between the sexes in the shape of the pectoral fins are evident from Fig. 16. The males have generally broader more rounded fins than the females.

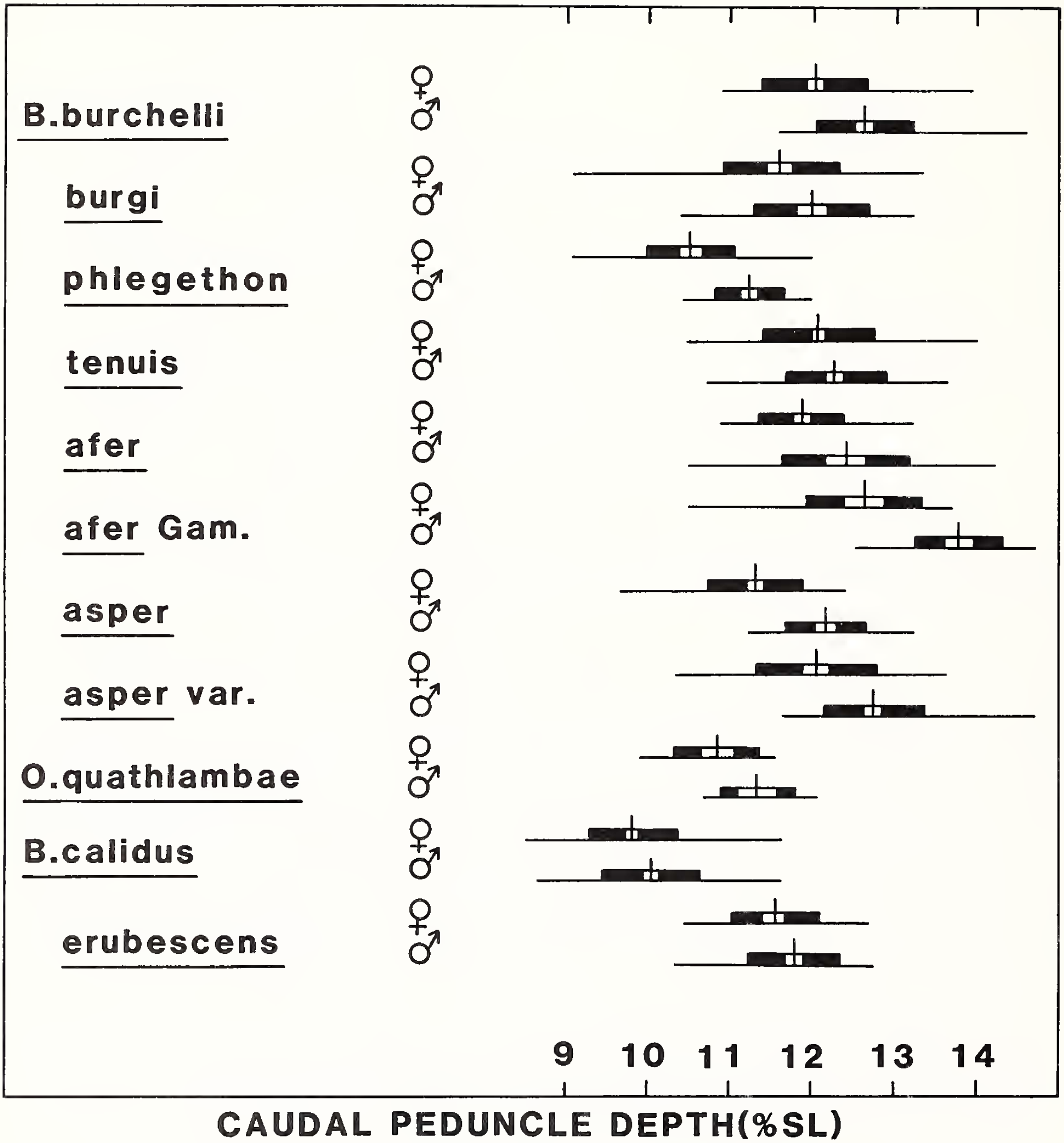

Fig. 13. Caudal peduncle depth (%SL) of redfin minnows.

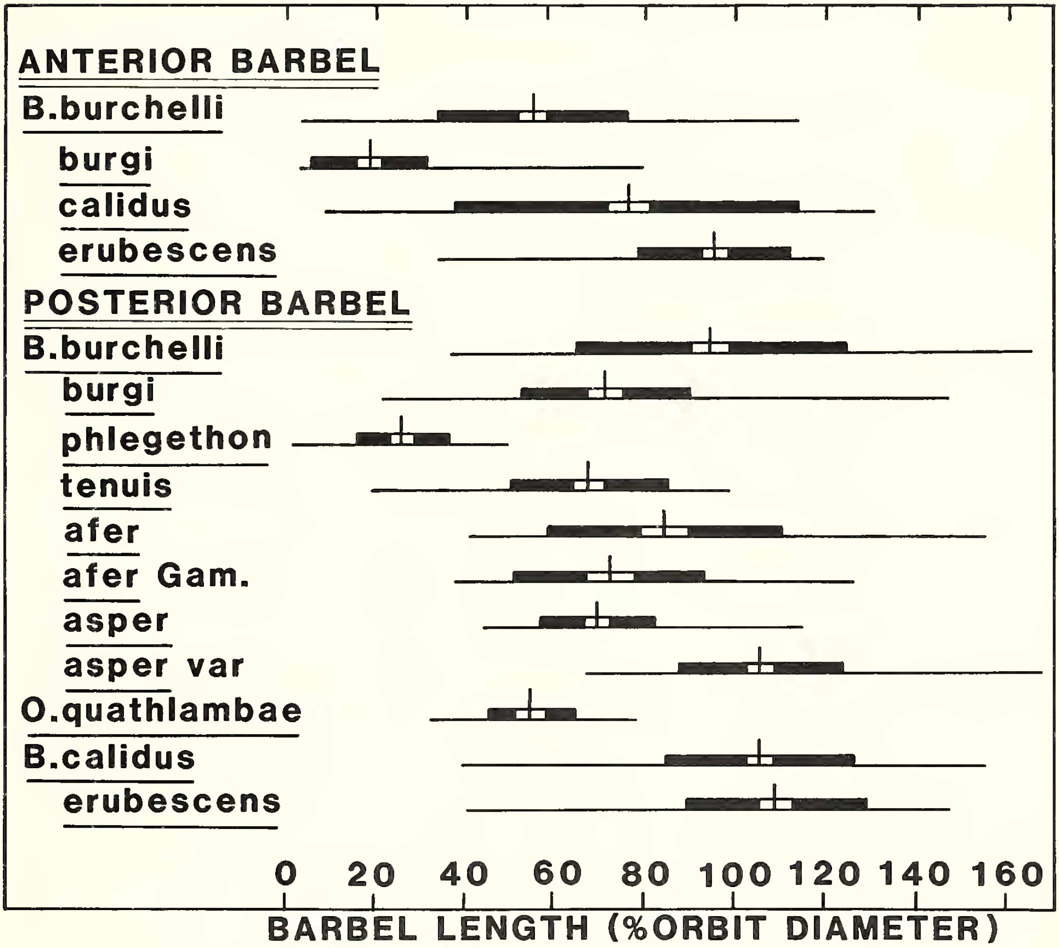

Fig. 14. The length of the anterior barbel and the posterior barbel (% Orbit diameter) of redfin minnows.

MERISTICS

(A) Fin rays

The number of fin rays in the dorsal, anal, pectoral and pelvic fins of redfin species are given in Table 2. In the dorsal and anal fins the number of unbranched rays is always difficult to determine accurately because the first one or two rays are very small and hidden from view. The form of the last unbranched ray in the dorsal fin is a useful character in *Barbus* (e.g. Boulenger, 1911) and is a prominent feature separating *B. calidus* and to a lesser extent *B. erubescens* from the other redfin species (Fig. 17). In *B. calidus* this ray is bony and serrated behind with only the tip being segmented and flexible. This ray is more flexible with a few reduced serrations in *B. erubescens*, and slender and flexible without serrations in all other redfin species.

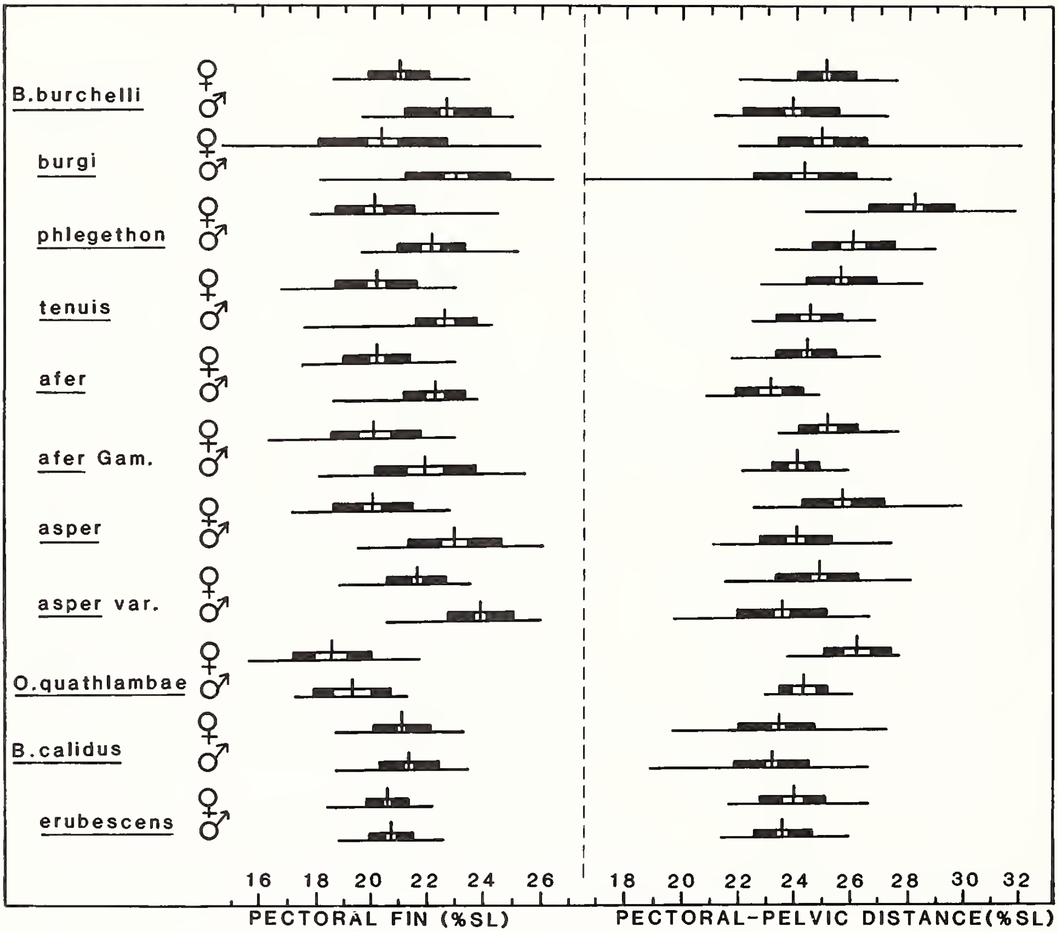

Fig. 15. The length of the pectoral fin and the pectoral to pelvic fin distance (%SL) of male and female redfin minnows.

Apart from *B. erubescens*, for which the modal number is eight, the redfins usually have seven branched dorsal fin rays (Table 2B). Similarly the majority of species have only fivebranched rays in the anal fin but this serves to emphasise the taxonomic significance of the modal six for *B. calidus* and seven for *B. erubescens* (Table 2D).

Pectoral and pelvic fin rays are seldom reported for African cyprinid species. The intraspecific range of variation in pectoral fin rays is broad which tends to diminish the value of any modal differences between the species (Table 2E). The same is true of the number of pelvic fin rays where all but *B. tenuis* have a mode of eight rays (Table 2F). The redfins have invariably 10 + 9 principal caudal fin rays.

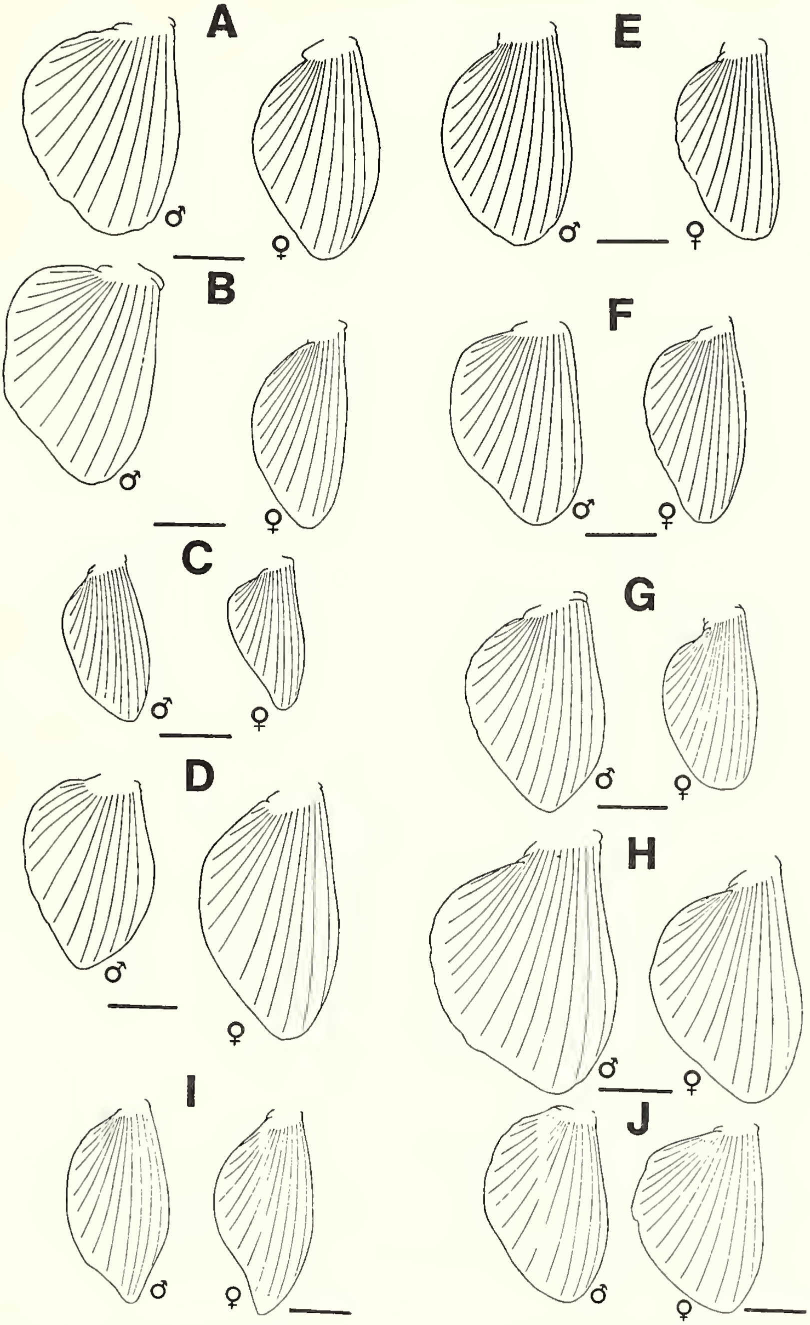

Fig. 16. Pectoral fin profiles of redfin minnows, dorsal view, right side. Scale bar = 5 mm. A. *B. burchelli*, B. *B. burgi*, C. *B. phlegethon*, D. *B. tenuis*, E. *B. afer*, F. *B. asper*, G. *B. asper* (variant), H. *O. quathlambae*, I. *B. calidus*, J. *B. erubescens*.

Table 2.

Fin ray counts for redfin minnows.

		A. Unbranched dorsal fin rays		B. Branched dorsal fin rays			C Unbranched anal fin rays			D. Branched anal fin rays				
Species/ (Group)	N	3	4	6	7	8	2	3	4	4	5	6	7	8
B. burchelli	179	74	105	8	166	5		130	49	1	171	7		
B. burgi	107	93	14	3	102	2	1	103	2		104	2		
B. phlegethon	90	63	27	4	85	1		85	5		89	1		
B. tenuis	96	69	27	6	88	2		90	6		93	3		
B. afer	105	37	68	2	103			105			104	1		
B. afer (Gamtoos)	50	14	36		50			48	2		49	1		
B. asper	110	11	99	5	104	1		95	15		109	1		
B. asper (variant)	142	54	88	5	133	4		137	5		142			
O. quathlambae	39	39		1	37	1		39			35	4		
B. calidus	300	10	290	1	287	12		280	20		2	278	20	
B. erubescens	110	33	77		27	83	1	107	2			7	96	7

		E. *Pectoral fin rays*								F. *Pelvic fin rays*		
Species (Group)	N	11	12	13	14	15	16	17	18	7	8	9
B. burchelli	179		1	40	90	44	4			7	160	13
B. burgi	107			4	46	42	12	2	1	1	80	26
B. phlegethon	90	1	4	36	42	7				11	78	1
B. tenuis	96		4	30	48	13	1			70	26	
B. afer	105			5	29	41	25	5			98	7
B. afer (Gamtoos)	50				4	29	12	5		2	46	2
B. asper	110				7	48	43	12		4	86	20
B. asper (variant)	142			9	41	68	22	2		8	123	11
O. quathlambae	38					8	21	9		4	31	3
B. calidus	280	1	10	141	116	12				28	237	15
B. erubescens	110	1		5	62	41	1			14	96	

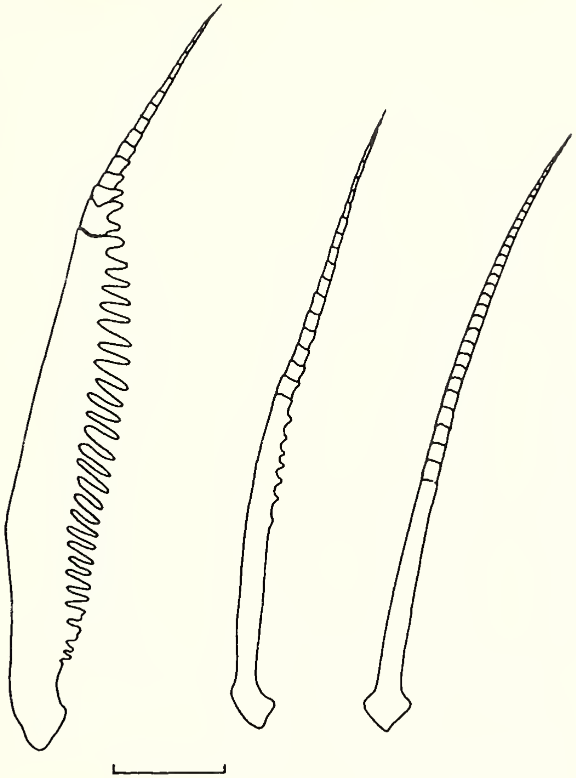

Fig. 17. The form of the last unbranched ray of the dorsal fin of redfin minnows. A. *B. calidus*, B. *B. erubescens*, C. *B. afer*.

(B) Scale counts.

Distribution frequencies of the various scale counts for redfin species are given in Table 3. There is a wide range of variation in the counts and only two species are really distinctive in the group on account of the size of their scales. These two species are *O. quathlambae*, which has exceptionally small scales, and *B. asper*, which also has relatively small scales.

Scale size, as assessed by scale counts, is an important factor in the problem of delimiting the two species *B. asper* and *B. afer*. The distribution frequencies of the lateral line counts of the different populations of the two species and their "variant" groups are given in Table 4 with graphic summaries in Fig. 18. A wide range of counts is characteristic of most of the samples. *B. afer* samples indicate a low mode of about 32 with the exception of the Kromme River sample where the mode is 29. In the Gamtoos system *B. afer* samples have a mode of 36 and those of *B. asper* 37. *B. asper* (variant) samples show a mode of 34 or 35 lateral line scales.

The summaries of lateral line counts for these samples depicted in Fig. 18 provide four taxonomic options. Firstly all the populations can be considered to be of a single polytypic species (Fig. 18A). Although the distribution curve is normal for this option the range of

TABLE 3.

The frequency distribution of the number of scales or scale rows in redfin species.

		A. *Lateral line scales*																					B. *Lateral line to dorsal fin scale rows*										
Species (Group)	N	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	4	5	6	7	8	9	10	11	12	13	14
B. burchelli	179					2	4	7	10	18	32	51	33	15	6	1								28	133	18							
B. burgi	107				2	4	14	17	23	19	14	9	4	1									6	66	35								
B. phlegethon	90					1			7	7	19	40	14	2									33	56	1								
B. tenuis	96								2	8	14	36	30	6									3	86	7								
B. afer	105	1	2	3	4	12	14	11	24	11	16	5	1	1									16	70	19								
B. afer (Gamtoos)	50										2	11	22	15										6	43	1							
B. asper	110											1	10	26	24	17	15	11	2	1	2	1			4	65	37	4					
B. asper (variant)	142					2	1	6	12	27	34	38	20	1	1									41	101								
*O. quathlambae**	34																												4	16	13		1
B. calidus	283										2	13	67	124	69	8								60	220	3							
B. erubescens	110											2	6	50	45	6	1							38	72								
		60	61	62	63	64	65	66	67	68	69	70	71	72																			
**O. quathlambae*	34	1	2	1	1	4	5	6	5	3	5			1																			

		C. Caudal peduncle scale rows															*D. Lateral line to pelvic fin scale rows*									
Species (Group)	N	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	3	4	5	6	7	8	9	10	11	12
B. burchelli	179			92	23	23	17	20	3	1								122	53	4						
B. burgi	107			98	4	4		1									2	76	29							
B. phlegethon	90	1	6	65	15	3											24	66								
B. tenuis	96		1	51	19	18	4	3									20	73	3							
B. afer	105	1	10	45	10	16	15	8									15	87	3							
B. afer (Gamtoos)	50					1	7	41	1									10	39	1						
B. asper	110							7	2	20	25	46	3	7					15	65	26	4				
B. asper (variant)	142			2	5	25	33	76		1							1	89	52							
*O. quathlambae**	34																					2	7	14	9	2
B. calidus	283			33	31	78	51	86	4								217	64								
B. erubescens	110						26	58	22	3	1						8	100	2							
		30	31	32	33	34	35	36	37	38																
**O. quathlambae*	34	1		8	5	6	4	7	2	1																

		E. *Predorsal scale rows*															F. *Lateral line to anal fin scale rows*								
Species (Group)	N	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	3	4	5	6	7	8	9	10	11
B. burchelli	176			2	13	23	49	40	35	7	4	3						105	72	2					
B. burgi	107	5	18	21	43	12	5	3									3	98	6						
B. phlegethon	90			1	8	21	34	15	10	1							43	46	1						
B. tenuis	96			1	8	35	15	11	5	13	7	1					6	89	1						
B. afer	105		2	27	49	23	4										20	81	4						
B. afer (Gamtoos)	50			1	5	21	11	5	6									11	39						
B. asper	110							1	7	15	26	32	17	10	1	1			18	81	10	1			
B. asper (variant)	142		3	14	32	36	19	14	16	6	1	1					1	68	73						
*O. quathlambae**	34																						12	18	4
B. calidus	283			2	12	64	101	79	18	5	2						16	206	61						
B. erubescens	110			1	22	30	39	11	4	2	1						1	91	18						
		28	29	30	31	32	33	34	35	36	37	38	39	40											
**O. quathlambae*	34	1			2	2	4	6	1	8	4	2	1	2											

TABLE 4.

Distribution frequency of lateral line scales in *Barbus afer*, *B. afer* (Gamtoos), *Barbus asper*, *B. asper* (variant).

		Lateral line scales																				
Population	N	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
B. afer																						
Sundays	40					3	4	4	12	8	9											
Swartkops	30						3	4	10	2	5	4	1	1								
Baakens	5						1	2			1	1										
Kromme	30	1	2	3	4	9	6	1	2	1	1											
B. afer (Gamtoos)																						
Couga	30										1	7	13	9								
Wit	10											1	4	5								
Loerie	10										1	3	5	1								
B. asper (variant)																						
Bloukrans	30							2	2	6	7	8	4	1								
Groot (Natures Valley)	30					1	1	1	7	5	8	5	2									
Keurbooms	22									3	6	10	3									
Knysna	30					1		3	3	7	9	4	3									
Goukamma	30									6	4	11	8		1							
B. asper																						
Groot (Gamtoos)	30												5	10	6	5	3	1				
Meiringspoort	30												1	3	7	6	5	4	2	1	1	
Van Wyksdorp	20													1	4	3	5	5			1	1
Kammanassie	30											1	4	12	7	3	2	1				

variation (from 25 to 45 lateral line scales) is twice that of any other species (or most African cyprinids). Furthermore no single redfin population including the very small scaled *O. quathlambae* approaches this range of variation. Acceptance of this option is against taxonomic consistency and is therefore rejected. The second option (Fig. 18B) in which three taxa are recognised including typical *B. afer*, typical *B. asper* and an intermediate form (*B. afer* (Gamtoos) and *B. asper* (variant) combined) is also rejected because the degree of range overlap between the groupings is too large for practical taxonomic purposes. In addition this option is not supported by other characters. The third option (Fig. 18C) where two taxa are recognised *viz.*, *B. asper* and a taxon that combines *B. afer*, *B. afer* (Gamtoos) and *B. asper* (variant), is the most acceptable, when all aspects are taken into consideration. This choice is the solution adopted in this revision. There is a minimum of overlap in counts between the two groupings presented and the range of variation within the groups is consistent with the range of lateral line scales of other redfin species. The fourth alternative (Fig. 18D), selecting two broadly overlapping taxa *viz.*, *B. afer* and a taxon combining *B. asper*, *B. asper* (variant) and *B. afer* (Gamtoos), is less optimal and not as strongly supported by other characters such as pigmentation and length of the gut.

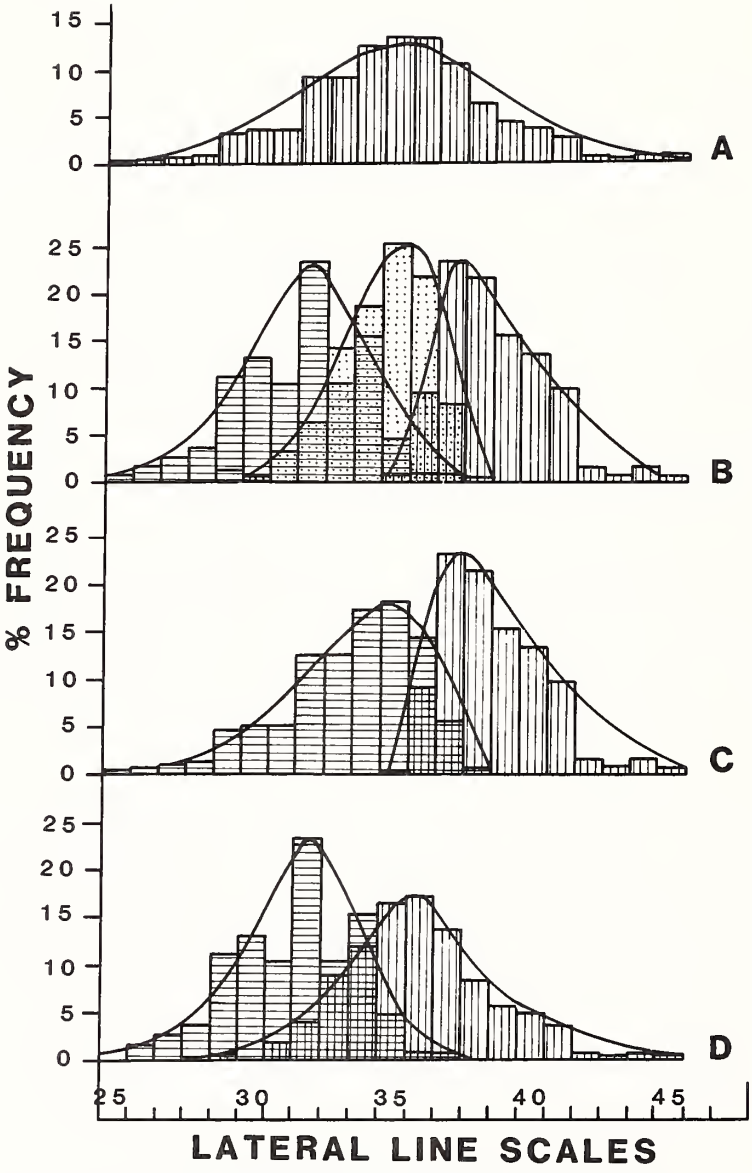

Fig. 18. Frequency distribution (%) of lateral line scales of *B. afer* and *B. asper*. A. All samples of both species combined. B. *B. afer*, *B. afer* (Gamtoos) + *B. asper* (variant), and *B. asper*. C. *B. afer* + *B. afer* (Gamtoos) + *B. asper* (variant), and *B. asper*. D. *B. afer*, *B. asper* + *B. afer* (Gamtoos) + *B. asper* (variant). Graph curves added by eye to assist interpretation.

SQUAMATION.

Barnard (1943) referred to a crowding of the nape scales in *B. asper* and *B. tenuis*. In *B. tenuis* the nape appears to be naked in some specimens. Scales over the breast region (from the isthmus to between the pectoral fins) of the flexible rayed species are small and embedded. In the small-scaled species *B. asper* and *O. quathlambae* the "naked" area extends beyond the pectorals to the belly region. The breast scales are not markedly reduced in *B. calidus* and *B. erubescens*.

Many cyprinid fishes have an elongated or triangular scale in the axil of the pelvic fins and this is true of the great majority of southern African species. A small axillary scale of this nature is present in *B. calidus* and *B. erubescens* but not in the other redfin species. In *O. quathlambae* the basal region of the pelvic, dorsal and anal fins is fleshy and without scales (and in life is bright red in colour—Skelton, 1974a).

SCALE RADII

Reports that the number of scale radii increase with age in cyprinids (Chu, 1935, Barnard, 1943, Jenkins and Lachner, 1971) suggest that the character should be used with caution in the taxonomy of these fishes. The number of scale radii of the juveniles and adults of four redfin species is given in Table 5. There is very little indication that the number of radii increases with age in these species. Discrepancies in the number of radii counted here and reported on for the same species by Barnard (1943) are probably due to the differences in interpretation of what constitutes primary radii.

The number of scale radii of the redfin species is given in Fig. 19 . Examples of the scales of the redfin species are illustrated in Fig. 20. The scales of *B. tenuis* are distinctive for having a relatively large number of primary and secondary radii, whereas *B. burchelli* and *B. burgi* have relatively few radii. The difference in the number of primary radii for *B. calidus* and *B. erubescens* is diagnostic (Skelton, 1974b). Another apparent difference that has not been quantified is the position of the scale focus. In *B. calidus* and *B. erubescens* the focus is closer to the anterior margin of the scale but it is more-or-less centrally located in the flexible-rayed species.

VERTEBRAE

The distribution frequency of various vertebral counts of redfin species is given in Table 6. Most species have modal counts of 36 or 37 vertebrae except *O. quathlambae* which has 39 and *B. calidus* and *B. erubescens* which have 37–38. The higher number of vertebrae in *O. quathlambae* is due to a greater number of precaudal vertebrae (Table 6B) whereas the increase in *B. calidus* and*B. erubescens* appears to be due to a slight increase in the number of caudal vertebrae.

Intraspecific variation in vertebral number is spread over three to five units. The number of vertebrae before the dorsal fin often correlates with the predorsal distance. *B. burgi* for example has fewer predorsal vertebrae than other redfins and is also the species with the shortest predorsal distance (see above). The dorsal fin of *B. calidus* is relatively far back, originating well behind the origin of the pelvic fins. The species also has a relatively high mode of predorsal vertebrae.

The pre-anal vertebral count is not often given in the literature. Interspecific overlap in this count is broad so it is interesting to record an exceptional case in intraspecific variation: the modal count of most populations of *B. burchelli* is 19 or 20, however, in a sample of nine

TABLE 5.

A comparison of primary scale radii from specimens of different sizes in four redfin species.

Species	N	SL (range) (mm)	$\overline{M}$ radii/scale
B. burchelli	13	31–39	9
	17	40–68	9,7
B. phlegethon	29	27,5–39	11,9
	30	43–57	12,2
B. tenuis	10	30–39	14,1
	18	41,5–66	16,5
B. erubescens	7	30,5–35,6	13,1
	30	62–95	13,6

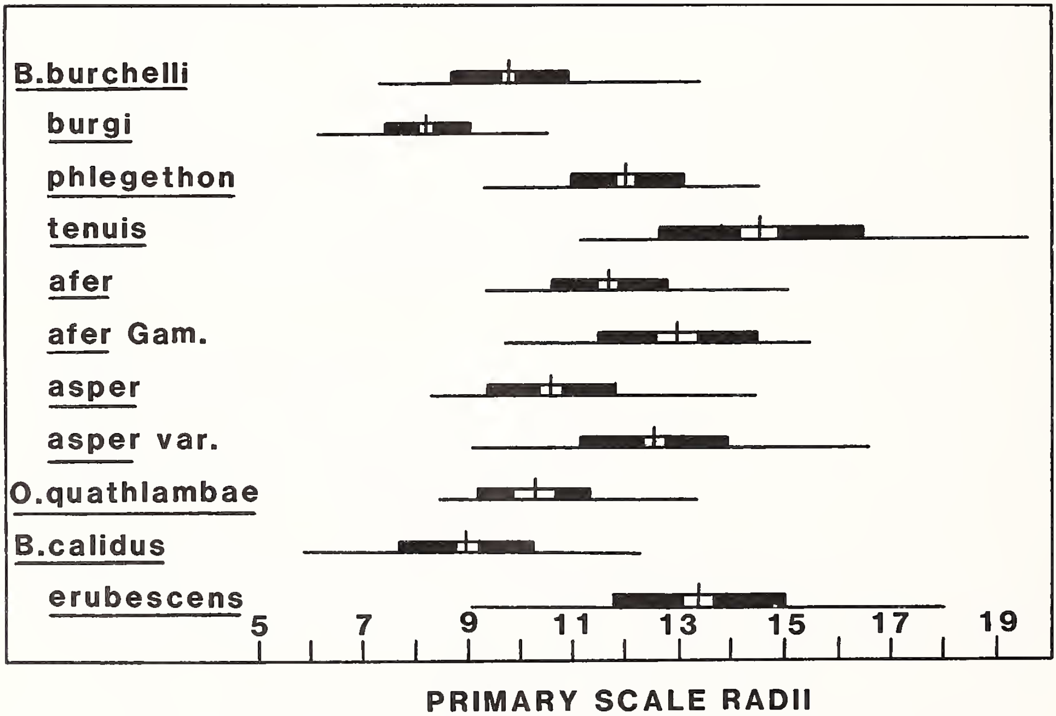

Fig. 19. The number of primary scale radii of redfin minnows.

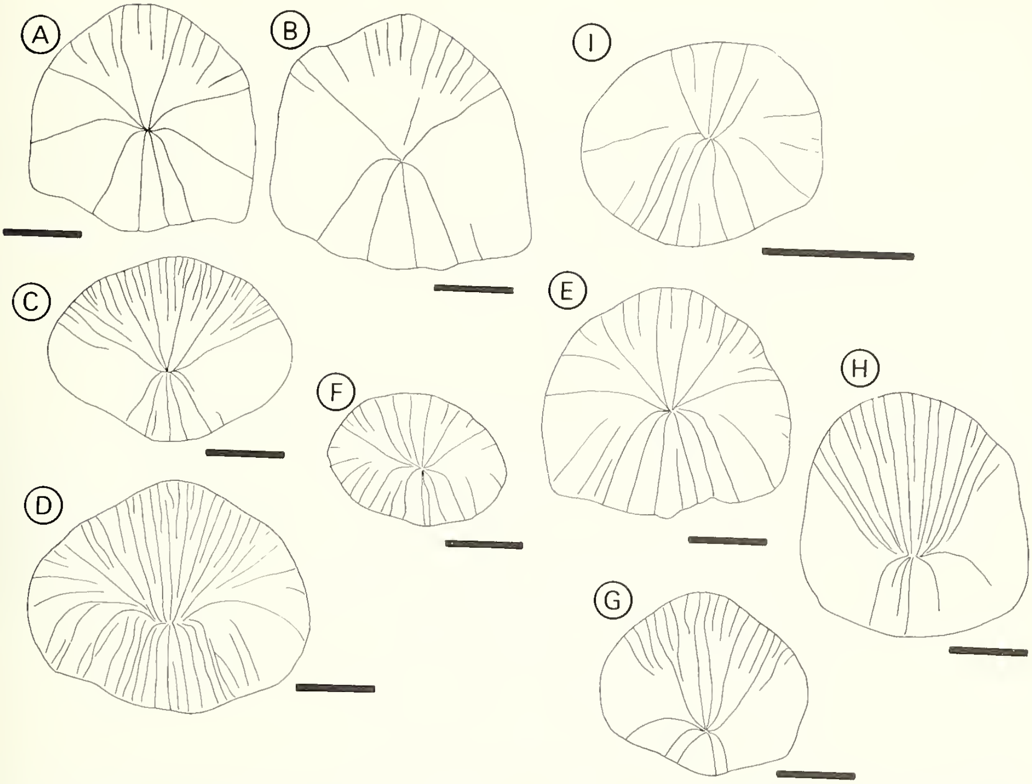

Fig. 20. Representative scales of redfin minnow species. Scale bar = 1mm. A. *B. burchelli*, B. *B. burgi*, C. *B. phlegethon*, D. *B. tenuis*, E. *B. afer*, F. *B. asper*, G. *B. calidus*, H. *B. erubescens*, I. *O. quathlambae*.

specimens from the Wit River (Bain's Kloof) seven specimens have 21 and two have 22 pre-anal fin vertebrae. This population stands out in other respects (pharyngeal teeth, mouth form and gut length) and its taxonomy warrants further attention.

Supraneural bones

Supraneural bones are well developed only in the serrated-rayed redfin species. *B. erubescens* has modal counts of six or seven supraneurals and *B. calidus* seven or eight (Table 7).

Pharyngeal bones and teeth

Three aspects of the pharyngeal bones and teeth were considered *viz.*, the length to width ratio of the pharyngeal bones, the number of teeth on the bones (tooth formula) and the form and shape of the teeth.

The length to width ratio of the pharyngeal bones of redfin species is shown in Fig. 21. The flexible-rayed species all have a similar lower ratio than the serrated-rayed species, i.e. the flexible-rayed species have relatively broader bones than the two serrated-rayed species.

Table 6.

Distribution frequency of vertebral counts in redfin species

		A. *Total vertebrae*								B. *Precaudal vertebrae*					
Species	N	33	34	35	36	37	38	39	40	17	18	19	20	21	22
B. burchelli	167		1	15	85	59	7			3	60	76	28		
B. burgi	135			6	53	67	8	1		2	36	75	23		
B. phlegethon	146			25	111	10				6	95	45			
B. tenuis	104	1	2	16	46	37	2			14	59	31			
B. afer	95			1	12	63	18	1			22	61	12		
B. afer (Gamtoos)	50				26	24					10	34	6		
B. asper	114			7	68	36	3			2	36	69	7		
B. asper (variant)	138			6	81	46	5			5	56	69	8		
O. quathlambae	31						3	16	12			1	9	16	5
B. calidus	369				27	227	111	4		1	95	265	8		
B. erubescens	151				1	80	67	3			25	122	4		

		C. *Caudal vertebrae*						D. *Predorsal vertebrae*							E. *Preanal vertebrae*				
Species	N	15	16	17	18	19	20	10	11	12	13	14	15	17	18	19	20	21	22
B. burchelli	167	3	19	50	73	20	2		61	103	3				2	82	67	14	2
B. burgi	136		8	46	60	20	2	7	82	45						29	88	19	
B. phlegethon	146		1	56	85	4			1	83	60	2			1	30	104	11	
B. tenuis	104		3	23	50	28			12	64	28			1	12	69	22		
B. afer	95		1	11	55	28			11	75	9					24	66	5	
B. afer (Gamtoos)	50		3	19	25	3				40	10					14	35	1	
B. asper	114		2	48	58	6			15	89	10				5	62	43	4	
B. asper (variant)	138		8	46	54	25	4		10	113	15				1	98	35	4	
O. quathlambae	31			2	10	14	5				6	22	3				1	24	6
B. calidus	369			12	181	160	15			70	263	36					52	268	49
B. erubescens	151			1	64	80	6		3	123	25						10	129	112

Chu (1935) showed that there is a general correlation between the feeding habits and length-width ratio of the pharyngeal bones of Chinese cyprinids; the more slender the bones the greater the tendency towards a carnivorous diet. The fact that *B. calidus* and *B. erubescens* have more slender bones than the flexible-rayed species does support Chu's (1935) findings because there are several other characters such as mouth form, gut length and pharyngeal tooth shape which suggest that the two former species are more carnivorous than most of the latter group of species. Within the flexible-rayed species as a group there are considerable differences in the teeth, tooth formula and gut length and the similarity of the length-width ratio of their pharyngeal bones is remarkable in the face of this diversity.

The distribution frequency of pharyngeal teeth of the redfins is given in Table 8, and a summary of the modal tooth counts is provided in Table 9. The usual *Barbus* formula of

Table 7.

Distribution frequency of supraneural bones in *B. calidus* and *B. erubescens*.

Species	N	Supraneurals 5	6	7	8	9
B. calidus	258	4	35	137	78	4
B. erubescens	134	—	50	81	3	—

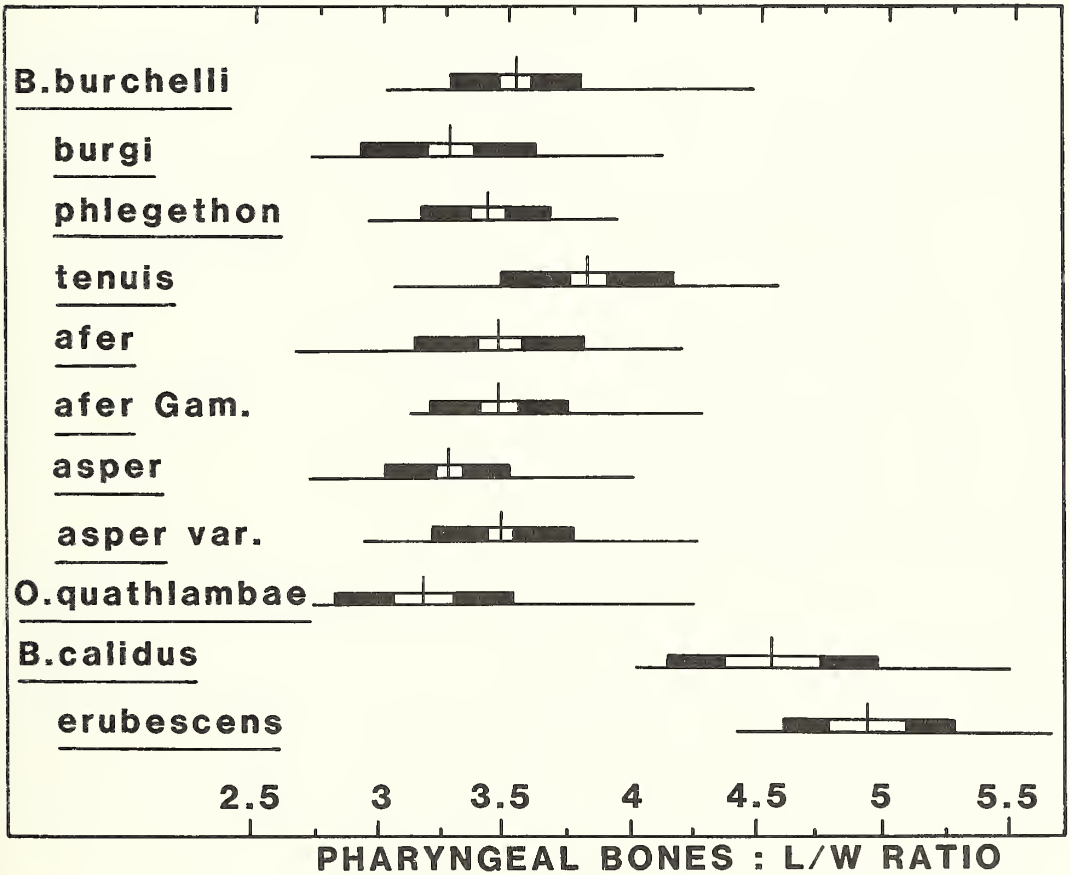

Fig. 21. The length/width ratio of the pharyngeal bones of redfin minnows.

Table 8.

Distribution frequency of pharyngeal teeth of redfin minnows.

		Left pharyngeal												*Right pharyngeal*										
		Outer row teeth			Middle row teeth				Inner row teeth				Inner row teeth				Middle row teeth				Outer row teeth		
Species	N	0	1	2	1	2	3	4	2	3	4	5	2	3	4	5	1	2	3	4	0	1	2
B. burchelli	61		10	51		9	52			1	15	45		2	15	44		7	54			10	51
B. burgi	30		10	20		4	26			1	9	20		1	6	22		6	22			9	19
B. phlegethon	32	5	24	3	1	5	26			4	13	15		1	8	23	1	6	25		6	24	2
B. tenuis	34	33	1			6	28			1	8	25		1	7	26	1	7	26		33	1	
B. afer	39	1	15	23		1	38			2	7	30		1	10	29		6	34		4	12	24
B. afer (Gamtoos)	30	2	13	15	1	2	27			1	9	20			8	22		5	25		2	12	16
B. asper	40	2	4	34		3	37			4	6	30		4	11	25		2	38			5	35
B. asper (variant)	50	5	14	31		8	41	1		4	18	28		1	14	35		4	46			16	34
O. quathlambae	12	11	1		1	4	7				12			1	11				12		12	1	
B. calidus	58		6	52		4	53	1		3	14	41		2	22	35		9	49	1		5	54
B. erubescens	30		4	26		2	28		1	6	23			6	24			3	27			3	27

Table 9.

Modal number of pharyngeal teeth in redfin species

	Left pharyngeal teeth			Right pharyngeal teeth		
Species	Row: O	M	I	Row: I	M	O
B. burchelli	2	3	5	5	3	2
B. burgi	2	3	5	5	3	2
B. phlegethon	1	3	5	5	3	1
B. tenuis		3	5	5	3	
B. afer	2(1)*	3	5	5	3	2(1)*
B. afer (Gamtoos)	2(1)*	3	5	5	3	2(1)*
B. asper	2	3	5	5	3	2
B. asper (variant)	2(1)*	3	5	5	3	2(1)*
O. quathlambae		3	4	4	3	
B. calidus	2	3	5	5	3	2
B. erubescens	2	3	4	4	3	2

O—outer (minor) row
M—middle row
I—inner (major) row
*certain populations

2, 3, 5–5, 3, 2 (Chu, 1935, Matthes, 1963, and Banister, 1973) is characteristic of most redfin species but tooth loss does occur in several of the species: *B. erubescens* has only 4 inner or major row teeth; *B. phlegethon* usually has only a single outer or minor row tooth; and *O. quathlambae* and *B. tenuis* have lost the minor tooth row entirely. There is also a tendency toward tooth loss from the outer row in some populations of *B. afer* and *B. asper* (variant).

An increase in the number of pharyngeal teeth was rarely encountered (Table 8). Of the seven specimens found with additional teeth, five are *B. burchelli* and four of these are from the same sample (collected in the Wit River, Bain's Kloof). Specimens from this sample also have the longest gut length for the species, display exceptional range of lip development and have more pre-anal fin vertebrae than other specimens of *B. burchelli*. One specimen each of *B. tenuis* and *O. quathlambae* was found with an outer row tooth. In the case of *O. quathlambae*, the specimen is the only one available from the Moremoholo River that was examined for this character and the possibility of others from this locality having minor row teeth cannot be ruled out.

The pharyngeal teeth of the redfins have not been previously described apart from those of *O. quathlambae* (Greenwood and Jubb, 1967). The shape of the pharyngeal teeth of the flexible-rayed redfin species conforms to a basic pattern which differs from that of the two serrated-rayed species. This pattern is evident in all the species despite the fact that there is considerable modification of shape in accordance with varied food habits.The evidence suggests that there has been convergence in the shape of the teeth for some of the species.

Scanning electron micrographs of the pharyngeal teeth are shown in Figs 22, 23 and 24. The crowns (occluding surfaces) of the three larger major row teeth of *B. burchelli*, *B. burgi*, *B. phlegethon* (Fig. 22a, b, and c respectively), *B. afer* and *B. asper* (Fig. 23a–d) are broad, recurved and obliquely spatulate in form. Each tooth has a major conical cusp as well as a smaller secondary cusp on the outer margin of the occlusion surface. The stems of these upper teeth in the row tend to be depressed and ovoid in cross-section. The fourth tooth in the row is stout and has a large major cusp and either one or two smaller secondary cusps of which the outer is usually the larger. The fifth tooth in this outer row is usually small and peg-like. The teeth on the inner rows are smaller but generally similar in shape to the major row teeth.

The pharyngeal teeth of *B. tenuis* (Fig. 22d) and *O. quathlambae* (Fig. 24e and f) are similar with the crowns only slightly expanded or spatulate and the major cusp recurved and placed obliquely on the outer rim of the crown. A secondary cusp is present at the outer base of the major cusp. There is also an inner secondary cusp on the fourth tooth in the row. The stems of the teeth are cylindrical and rounded in cross-section.

Of the flexible-rayed redfins the pharyngeal teeth of *B. tenuis* and *O. quathlambae* are most similar to the two serrated-rayed species *B. calidus* (Fig. 24a and b) and *B. erubescens* (Fig. 25c and d). The pattern of the teeth of the latter two species is nevertheless distinct from the pattern of all flexible-rayed species. The teeth of *B. calidus* have cylindrical stems and a narrow recurved crown with a prominent terminal hooked cusp. There are ridge rims on either side of the crown and no distinct secondary cusps. The teeth of the two inner rows are smaller versions of the upper major row teeth. The major row teeth of *B. erubescens* are stout and peg-like with a large pointed terminal cusp. Only the uppermost tooth is recurved to any extent.

The major differences between the shape of the pharyngeal teeth of the two redfin groups are that the flexible-rayed species have spatulate crowns with the major cusp off-set to the outer rim and a secondary cusp on this outer rim, whereas the serrated-rayed redfins have cylindrical

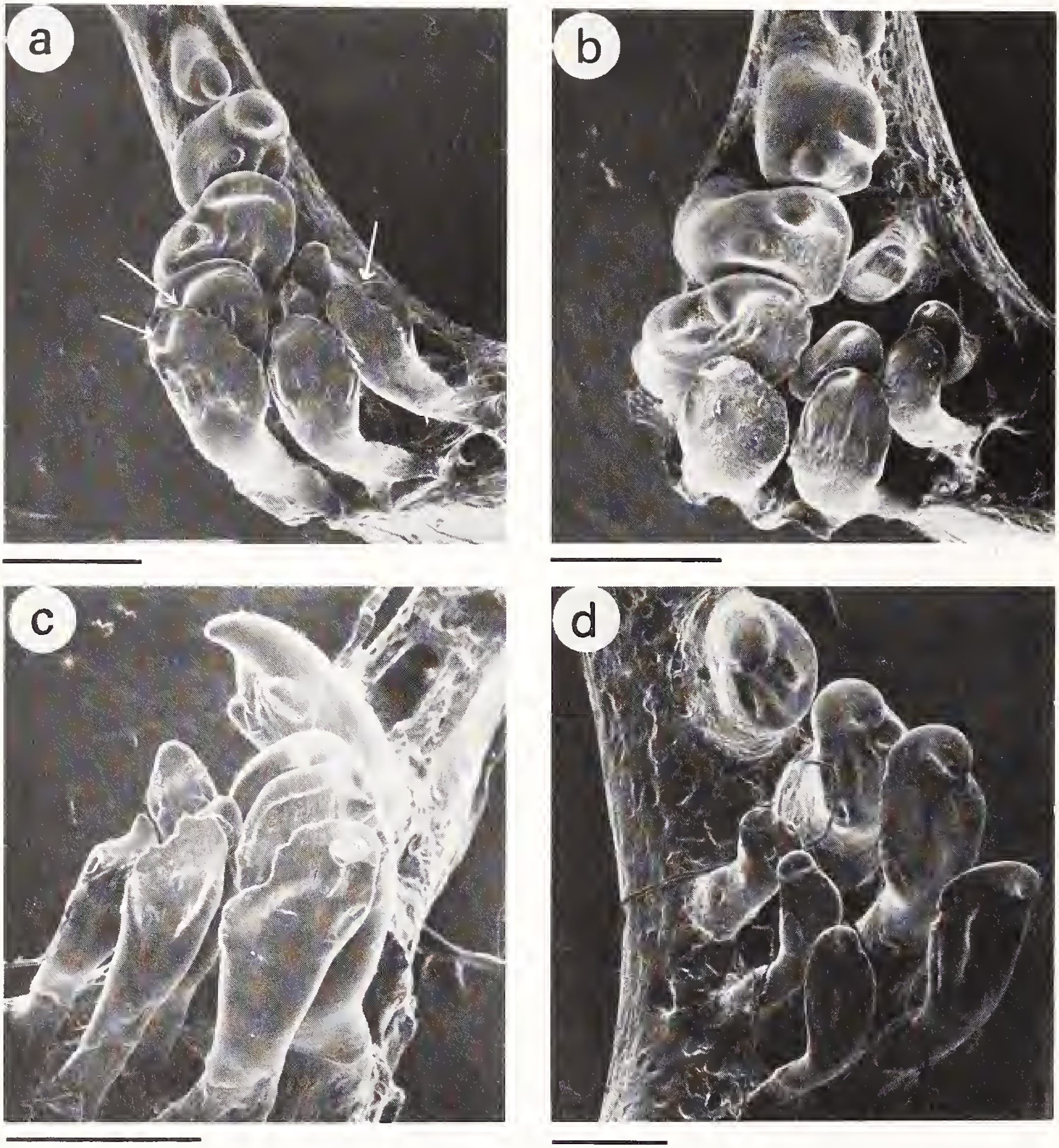

Fig. 22. The occlusal view of the pharyngeal teeth of redfin minnows. Scale bar = 0,5 mm. a. *B. burchelli*, AMG/P 1566, 52,5 mm SL, right arch; arrows direct to the lateral placement of major cusps. b. *B. burgi*, AMG/P 1847, 41 mm SL, right arch. c. *B. phlegethon*, AMG/P 722, 46 mm SL, left arch. d. *B. tenuis*, AMG/P 1935, 66 mm SL, left arch.

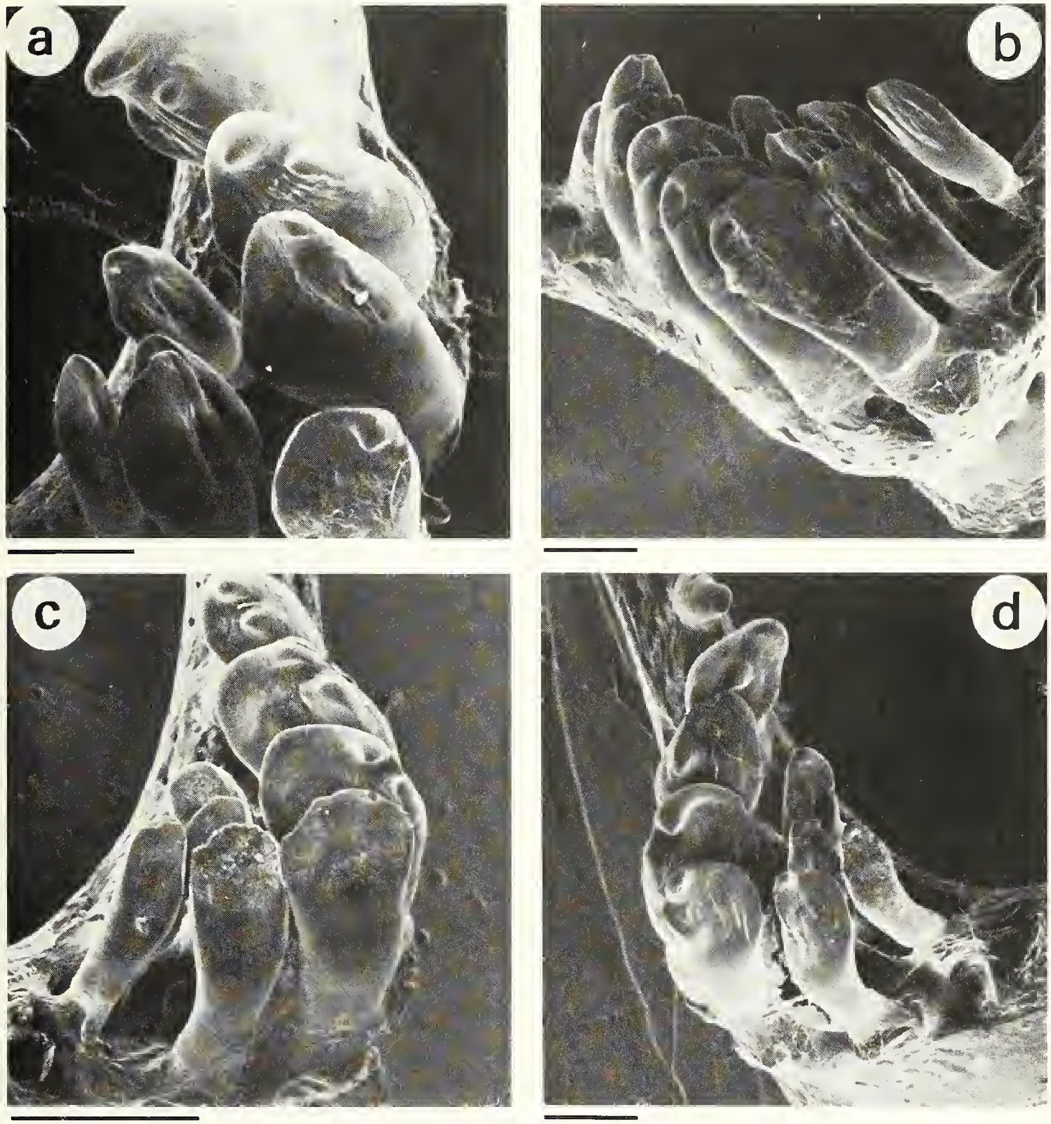

Fig. 23. The occlusal view of the pharyngeal teeth of redfin minnows. Scale bar = 0, 5 mm. a. *B. afer*, AMG/P 3460, 53 mm SL, left arch. b. *B. afer* (Gamtoos), AMG/P 1415, 58 mm SL, right arch. c. *B. asper*, AMG/P 1744, 47 mm SL, left arch. d. *B. asper* (variant), AMG/P 2656, 56 mm SL, right arch.

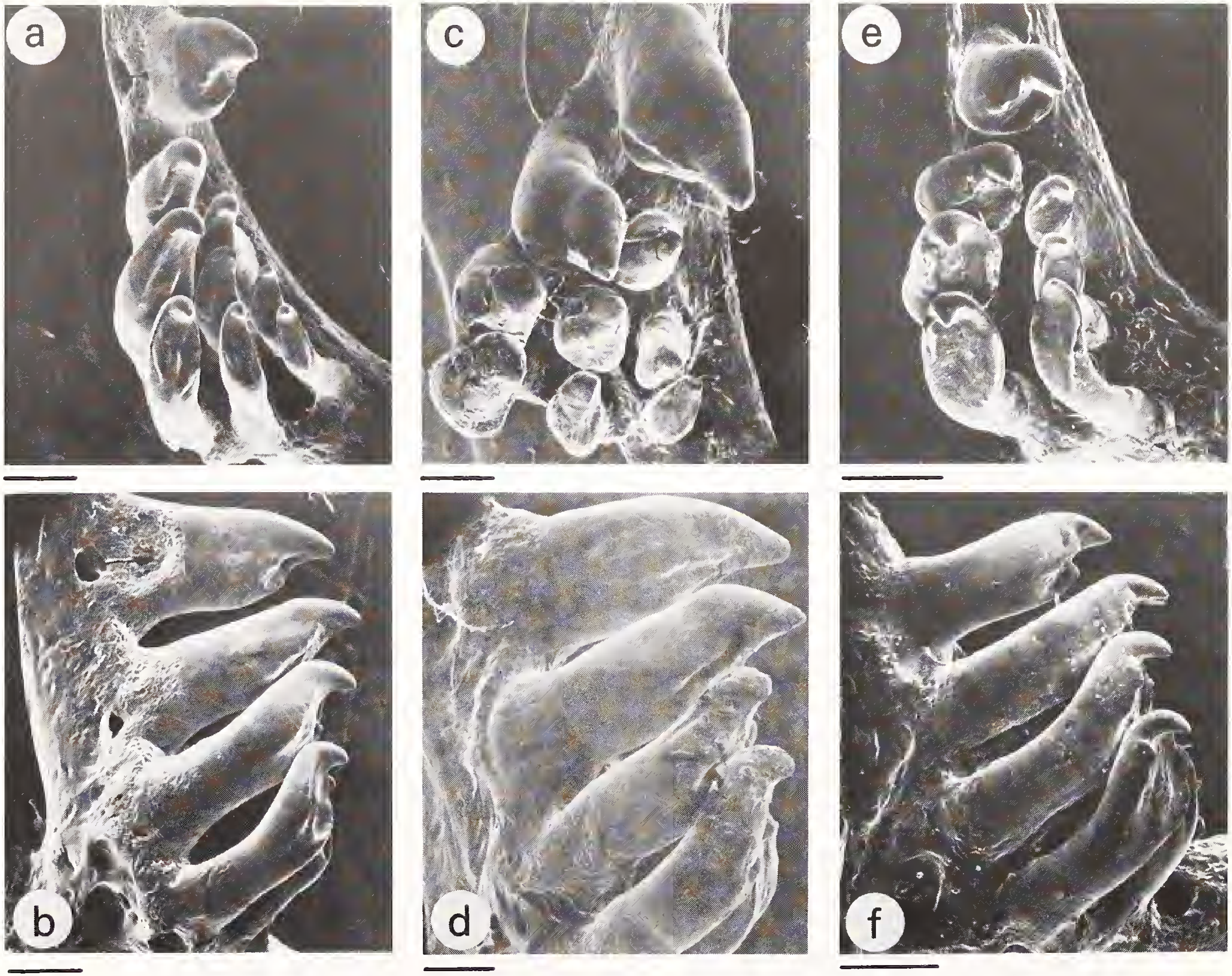

Fig. 24. Occlusal and lateral (postero-medial) views of the pharyngeal teeth of redfin minnows. Scale bar = 0,5 mm. a and b. *B. calidus*, AMG/P 1844, 65 mm SL, right arch. c and d. *B. erubescens*, AMG/P 1866, 65 mm SL, right arch. e and f. *O. quathlambae*, AMG/P 1877, 82 mm SL, right arch.

teeth with narrow crowns and large conical or pointed terminal major cusps and no distinct secondary cusps.

Gut length and coiling pattern

In fishes as well as in other animals the length of the gut (or alimentary canal within the body cavity) is most often correlated with the diet of the species (Nikolsky, 1963, Weatherley, 1972, and Ribble and Smith, 1983). Short guts are associated with carnivory and increasing gut length is associated with an increasing tendency to herbivory. Gut length and pattern of coiling or flexure have been used as a systematic character in fishes in general (e.g. Kafuku, 1958, and Yamaoka, 1985), frequently so in cyprinids. For most smaller African cyprinid species gut characteristics have not been described or well used as a taxonomic character. On the whole very little attention has been paid to the gut of redfin species. Smith (1841) mentioned that his sub-genus *Pseudobarbus* (which included *B. burchelli*) was characterised by the "intestinal canal long and contorted". Greenwood and Jubb (1967) referred to the short gut of *O. quathlambae*, which character was one of the reasons why the species was removed from the genus *Labeo*.

Redfin species show a relatively wide range of gut length (Fig. 25). Three characteristic groups of regression lines are formed by the plots of gut length against standard length for the various species or, in two cases, for different populations of a species. Short guts that more or less equal the standard length characterize four species, *B. tenuis*, *B. calidus*, *B. erubescens* and *O. quathlambae*. Gut lengths of about 2–2,5 times the standard length in adults characterize a second group which includes *B. burchelli*, *B. burgi* (in part, specimens from the Berg River system except those from the locality Groot Drakenstein), *B. phlegethon*, *B. afer*, *B. afer* (Gamtoos), and *B. asper* (variant). Relatively long guts which in adults exceed 2,5 times the standard length characterizes the third group which includes *B. asper*, and the Verlorevlei and Groot Drakenstein populations of *B. burgi*.

The pattern of involution or coiling of the gut of the redfins is illustrated diagrammatically in Fig. 26. The increase in length for the different species is accommodated by progressive involution within the same pattern. The species with short guts usually only have a single "S" flexure which may become slightly more involuted in *B. tenuis*. The intraspecific variation of gut length increases markedly with increasing gut length.

Mouth

B. calidus and *B. erubescens* have large terminal "U"-shaped mouths and all other redfins have sub-terminal or inferior crescent-or sickle-shaped mouths, with relatively thick lips. An exceptional degree of intraspecific variation in mouth form is found in the population of *B. burchelli* from the Wit River in Bain's Kloof in which the usual lips (Fig. 27A) are retracted from the lower jaw and replaced by a firm but not keratinised sheath (Fig. 27B).

Tubercles

Head, body and fin tubercles are prominent features of many cyprinid fishes (Wiley and Collette, 1970, and Collette, 1977). For African cyprinids tubercles are better known in the bariliine and labeine species than they are for the barbines (e.g. Howes, 1980, and Reid, 1985). The large tubercles of certain redfins are well known (Barnard, 1943, and Jubb, 1965 and 1967). Recently Cambray and Stuart (1985) gave some details of the development of tubercles in *B. burchelli*. In the present study the tubercles and the pattern they form is described for all the redfin species as these structures have been found to be useful as taxonomic characters.

Two kinds of tubercles are present in the redfins: *B. calidus* and *B. erubescens* have minute

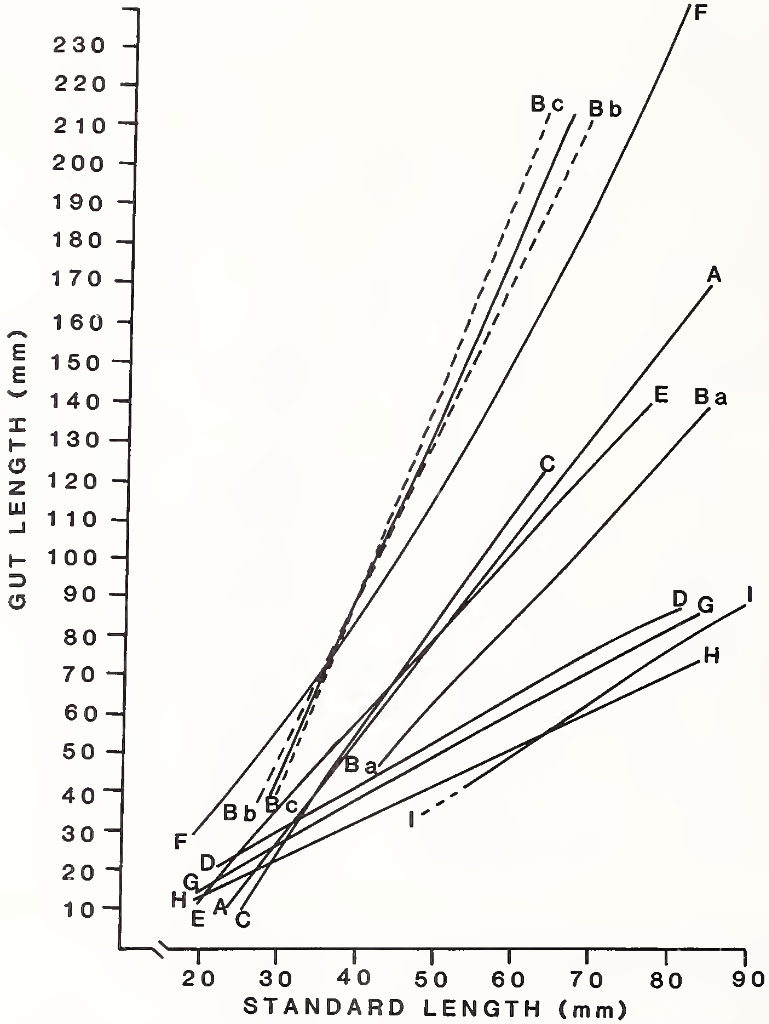

Fig. 25. The length of the gut of redfin minnows as given by lines of regression. A. *B. burchelli*, $Y= -50{,}5 + 2{,}6X$, $r^2 = 0{,}8651$. B. *B. burgi*, (a) $Y = -51{,}2 + 2{,}26X$, $r^2 = 0{,}8414$, (b) $Y = -81 + 4{,}3X$, $r^2 = 0{,}9051$, (c) $Y = -119 + 5{,}25X$, $r^2 = 0{,}9263$. C. *B. phlegethon*, $Y = -63{,}75 + 2{,}9X$, $r^2 = 0{,}8564$. D. *B. tenuis*, $Y = -4{,}4 + 1{,}1X$, $r^2 = 0{,}9026$. E. *B. afer*, $Y = -31{,}83 + 2{,}24X$, $r^2 = 0{,}9495$. F. *B. asper*, $Y = 0{,}36 \times X^{1{,}47}$, $r^2 = 0{,}8901$. G. *B. calidus*, $Y = -8{,}5 + 1, 13X$, $r^2 = 0{,}9528$. H. *B. erubescens*, $Y = -5{,}58 + 0{,}93X$, $r^2 = 0{,}9656$. I. *O. quathlambae*, $Y = -30{,}8 + 1{,}34X$, $r^2 = 0{,}8995$.

"erupted pimples", and the flexible-rayed species have small and large conical tubercles. Conical tubercles are deciduous, hypertrophied epidermal structures with a distinct outer layer or cap of keratin (Fig. 28c). These develop on the head, scales and fins of adult males, especially during the spring and summer months (Barnard, 1943, and Cambray and Stuart, 1985). Tubercle buds and small tubercles also occur on larger females (pers. obs., and Cambray and Stuart, 1985). The

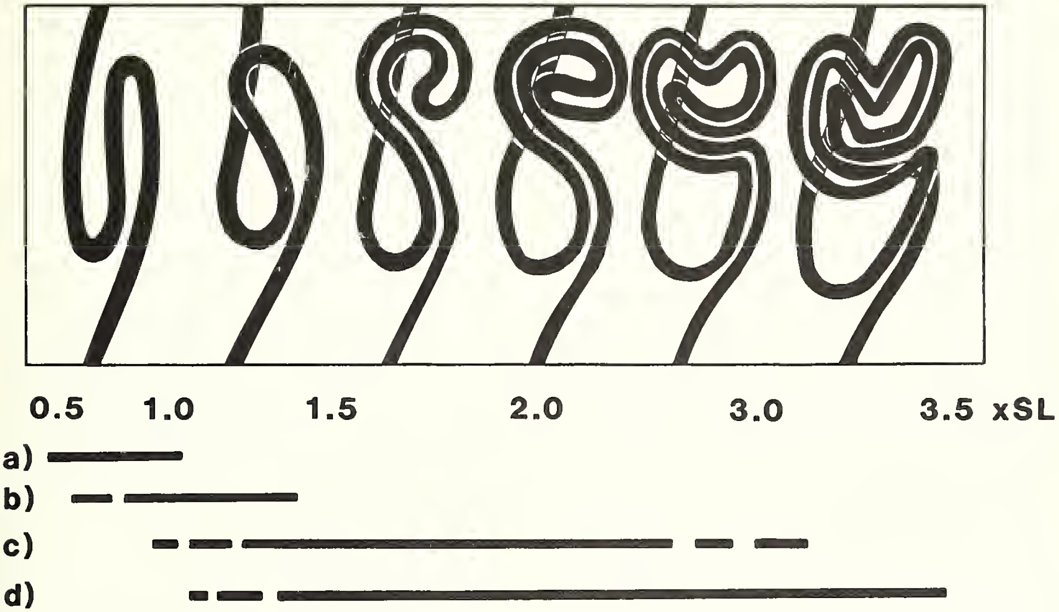

Fig. 26. Coiling pattern of the gut in redfin minnows, giving indication of correlation of length with standard length (SL) and the range of length variation and extent of involution for each species. a. range of *B. calidus*, *B. erubescens* and *O. quathlambae*. b. range of *B. tenuis*. c. range of *B. afer*, *B. burchelli*, and *B. phlegethon*. d. range of *B. asper* and *B. burgi*.

fact that the tubercles are correlated with sexual maturity and breeding condition strongly suggests that they have some function associated with breeding activity. In *B. burchelli* the first signs of wear and sloughing off of the larger tubercles was in November when spawning commenced. Cambray and Stuart (1985) suggest that this indicates they are used to defend a territory. The smaller tubercles on the scales and fins of the flexible-rayed species (see Figs 28, 29 and 30) are, however, more likely to be involved in a body contact function, probably during the spawning act itself (Wiley and Collette, 1970, and Collette, 1970).

There are differences in the size and degree of development of tubercles among the flexible-rayed redfins but a common pattern of distribution seems to exist within the group. For comparative purposes this pattern will be described for *B. burchelli* (Fig. 31). The actual number of tubercles on the head of an individual depends on several factors including age (size), and time of the year. Younger smaller fishes have fewer tubercles than older larger specimens. A peak of development occurs during the summer months around November–January. The pattern of tubercle distribution on the head of *B. burchelli* is as follows: bilateral groups of tubercles develop on the snout. The median tubercles here can measure up to 1,8 mm basal diameter and 1,6 mm in height, and there are five or six tubercles in each group. A row of progressively smaller tubercles extends in an arc above each nare to the antero-dorsal edge of the orbit and then continues posteriorly along the dorsal edge of each orbit. A number of generally smaller tubercles are scattered irregularly over the crown of the head. Apart from the occasional one, tubercles are not found on the cheeks, below the orbit or on the ventral surface of the head.

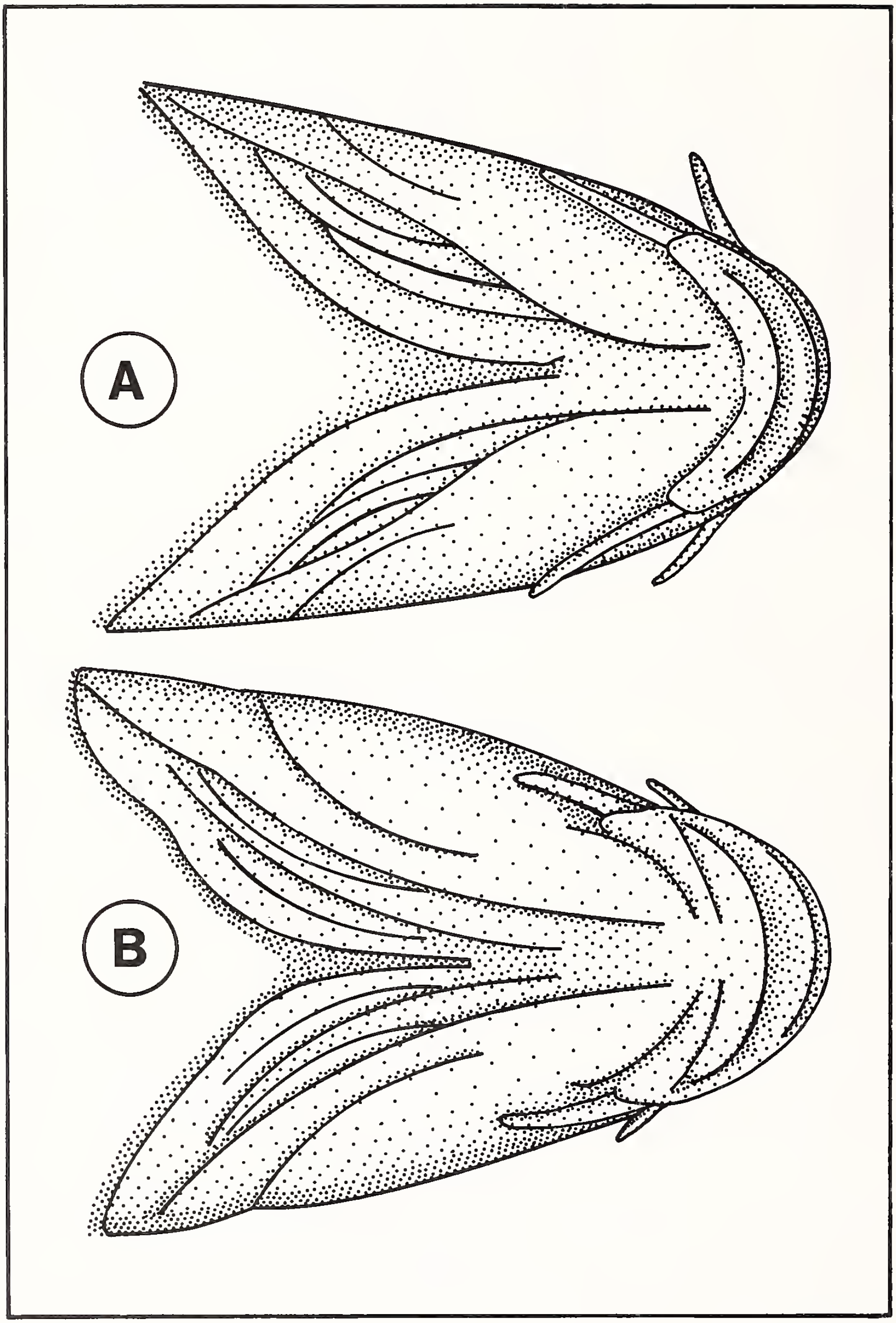

Fig. 27. Examples of different mouth forms in *B. burchelli* : A. lower lips not retracted, specimen from AMG/P 4972, and B. lips retracted from rim of lower mandible, specimen from AMG/P 1411.

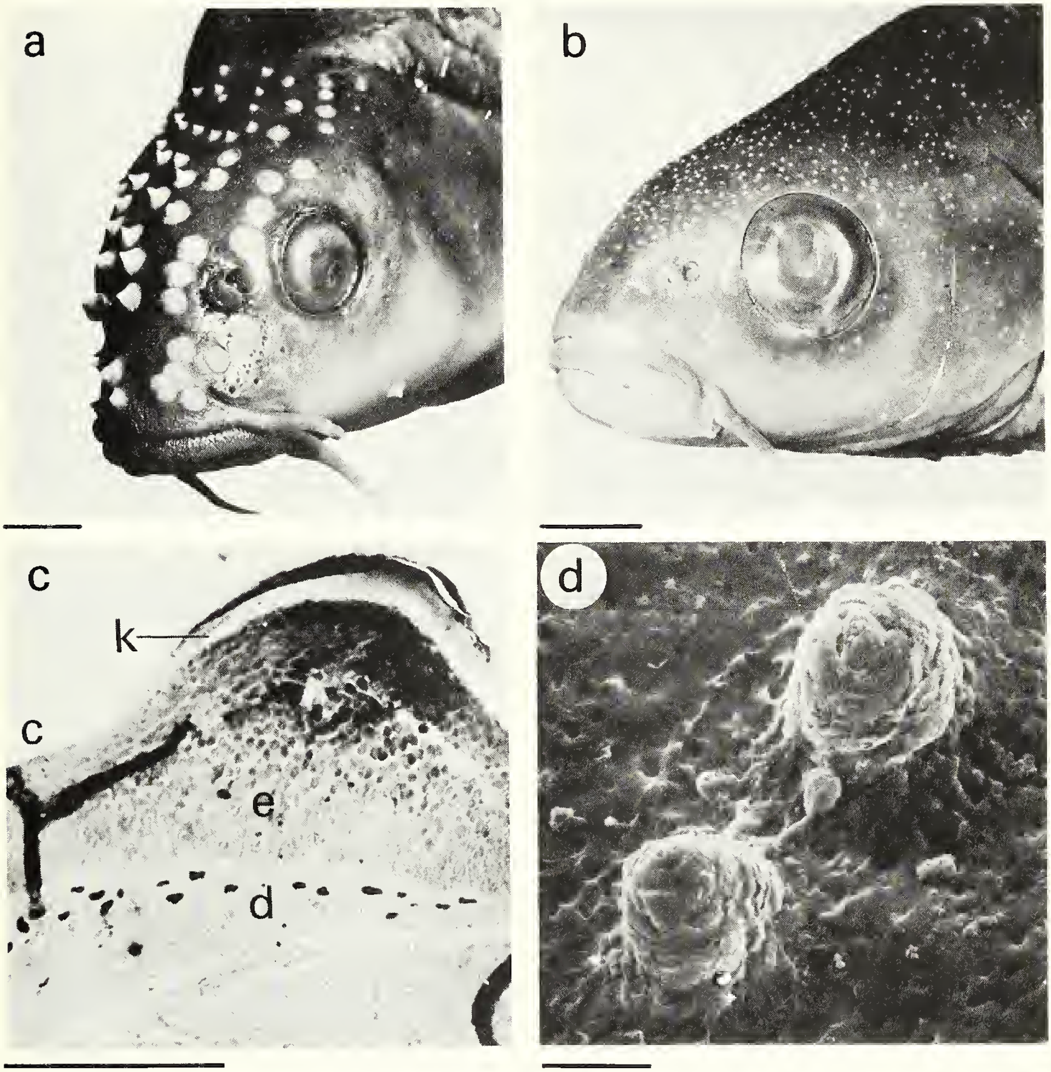

Fig. 28. Aspects of head tubercles of redfin minnows. a. *B. burchelli*, AMG/P 7223, 99 mm SL. Scale bar = 5 mm. b. *B. erubescens* (paratype), AMG/P 2074, 85 mm SL. Scale bar = 5 mm. c. Section of head tubercle from *B. afer* AMG/P 3786. c—canal, d—dermis, e—epidermis, and k—keratin. Scale bar = 0,3 mm. d. *B. erubescens* (paratype), AMG/P 2074, head tubercles, SEM. Scale bar = 0,05 mm.

From five to ten small (about 0,08 mm diameter) conical tubercles are arranged in a single linear series along the free edge of most of the scales of sexually mature males (Fig. 29c). Chest and belly scales only lack these tubercles. Bands up to five or six across (about 0,6–0,7mm in width) develop on the dorsal side of the pectoral fin branched rays (Fig. 29a). The individual

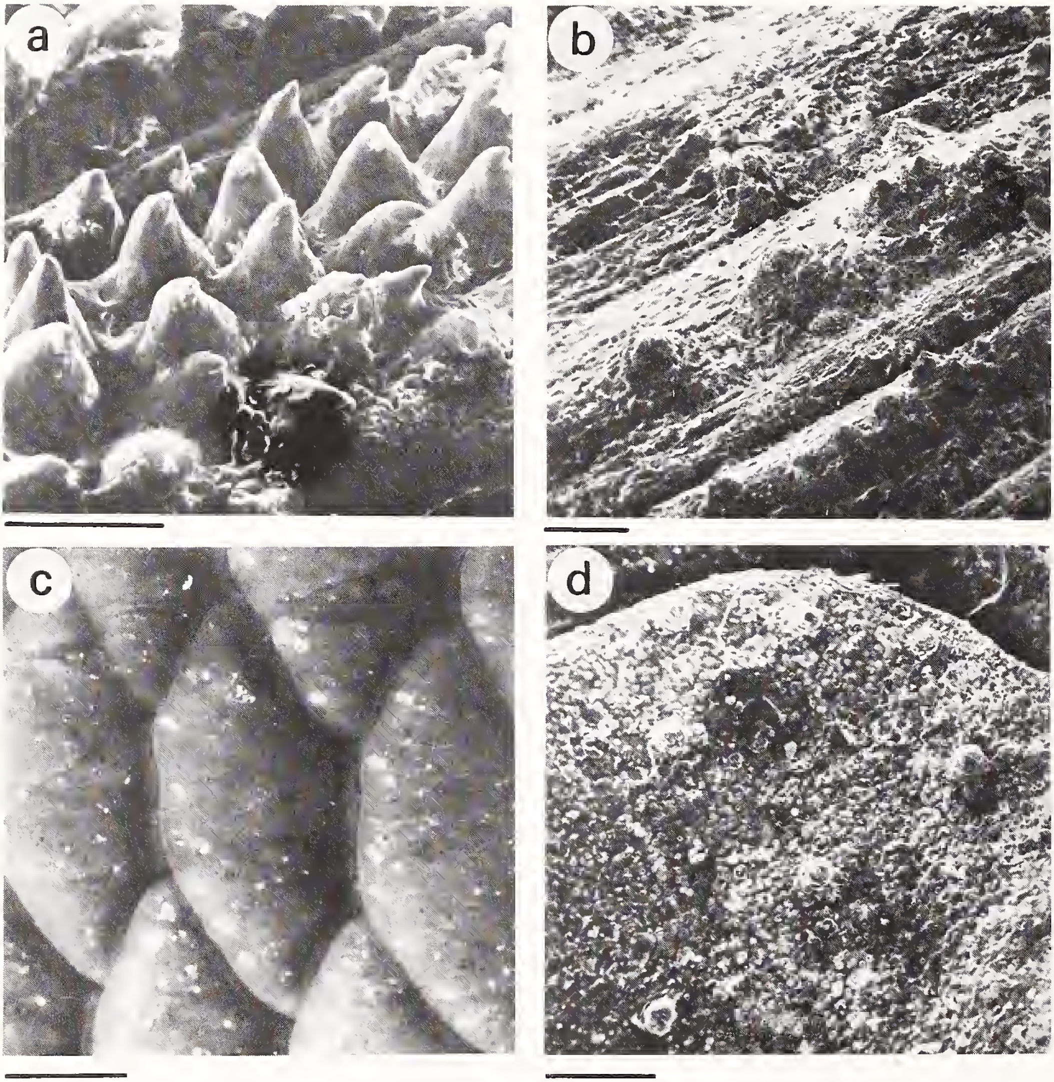

Fig. 29. Tubercles on the pectoral fins and scales of redfin minnows. a. *B. burchelli*, AMG/P 2077, pectoral fin tubercles. Scale bar = 0,1 mm. b. *B. erubescens*, AMG/P 2074, pectoral fin tubercles. Scale bar = 0,25 mm. c. *B. burchelli*, AMG/P 3472, body scales. Scale bar = 1,0 mm. d. *B. erubescens*, AMG/P 2074, scale. Scale bar = 0,25 mm.

tubercles in the bands are small, from 0,1–0,2 mm diameter. Single rows of tubercles develop on the fin rays of other fins.

The tubercles of *B. burgi* are similar to but relatively smaller than those of *B. burchelli*. Well developed tubercles on the snout of a large specimen (78 mm SL) of *B. burgi* measure 0,8 mm diameter and height. They are also more numerous and each group on the snout has from 10 to 15 tubercles.

The tubercles of *B. phlegethon* are seldom observed probably because of all the redfin species they are the most poorly developed (Fig. 30b and d). Both Barnard (1943) and Jubb

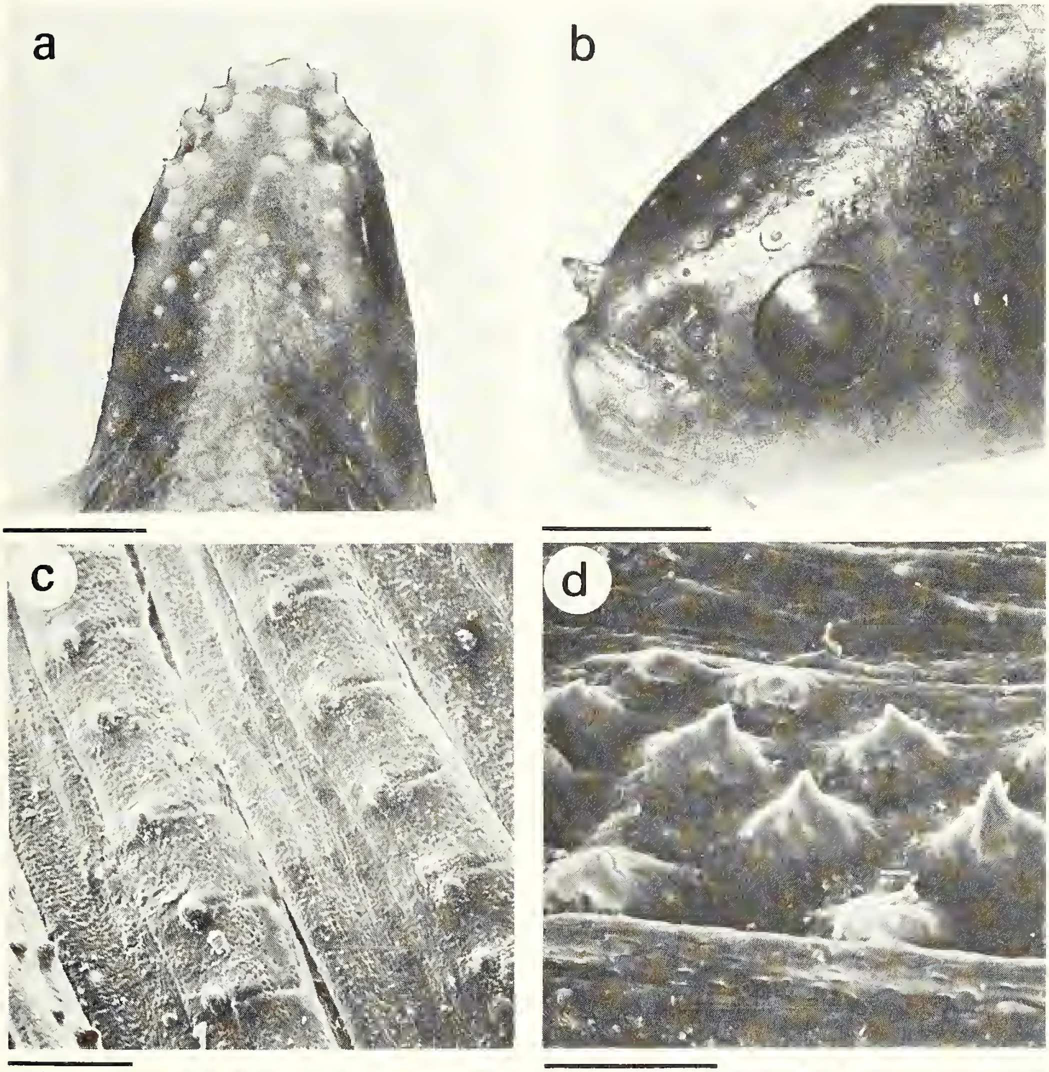

Fig. 30. Tubercles of redfin minnows. a. dorsal view of head of *B. tenuis*, AMG/P 3455, 62 mm SL. Scale bar = 5 mm. b. head of *B. phlegethon*, AMG/P 7366, 70 mm SL. Scale bar = 5 mm. c. *B. tenuis*, AMG/P 3455, pectoral fin. Scale bar = 0,25 mm. d. *B. phlegethon*, AMG/P 1399, pectoral fin. Scale bar = 0,1 mm.

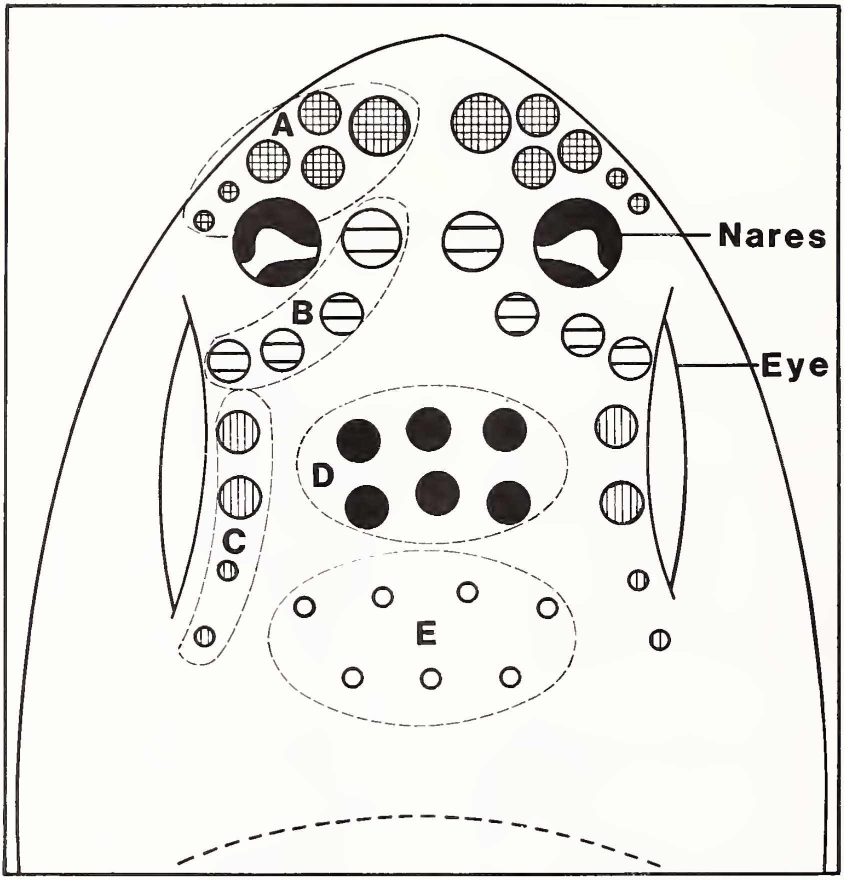

Fig. 31. Diagrammatic representation of pattern of head tubercles on flexible-rayed redfin minnows. A. cluster on snout, B. row above nares, C. row above orbit, D. anterior dorsal cluster, E. posterior dorsal cluster.

(1965 and 1967) did not report tubercles on this species. The tubercles occur in the same pattern on the head as for *B. burchelli* and weak bands are found on the pectoral fin rays but tubercles have not been observed on the scales of *B. phlegethon*.

Contrary to the findings of Barnard (1943) and Jubb (1965 and 1967) tubercles have also been observed on *B. tenuis* (Fig. 30a and c). Again the head pattern is similar to *B. burchelli* but there are fewer tubercles on the snout (four or five per group). Tubercles in single widely-spaced rows only occur over the pectoral fin rays (Fig. 30c) and rays of other fins. In this species a linear row of tubercles occurs along the free edge of each body scale (apart from those on the ventral surface).

Large conical head tubercles are characteristic of the males of both *B. afer* and *B. asper*. Jubb (1965 and 1967) has a photograph of the heads of two tubercled males of *B. asper* (variant) from the Homtini River. There are from three to five tubercles per group on the snout and the tubercles on the top of the head tend to be clustered into an anterior and a posterior group. The scales have a single marginal row and there are bands of tubercles (two to three across) over the pectoral fin rays.

Skelton (1974a) described and illustrated the tubercles of *O. quathlambae*. In this species the head tubercles are more numerous and smaller than in any other flexible-rayed redfin but they are distinctly conical and the basic pattern is the same. By way of exception tubercles do occur over the operculum and below the orbit. Each scale has one or two tubercles only and there are well developed bands of compressed tubercles on the pectoral fin-rays. Single tubercle rows occur on other fins.

There are no large conical tubercles on the head of *B. calidus* or *B. erubescens*. Breeding adults of both sexes of these two species develop tiny (0,1 mm diameter) epidermal excrescences (Fig. 28b and d) called "pimples" by Barnard (1943). The pimples are scattered over the head dorsum as well as in clusters over the opercula and cheeks. Similar pimples are scattered over the exposed surfaces of the scales (Fig. 28d). Single widely-spaced rows occur on the rays of all fins (Fig. 29b). The tubercles are usually better developed in males than in females.

LIVE COLOUR AND PIGMENTATION

Live specimens of all the redfin species were observed during the course of the study. Different ecological and physiological situations clearly affect the expression of colour and pigmentation of individuals but descriptions characteristic of each species are still useful for taxonomic purposes. Colour illustrations of redfin species have been given previously by Smith (1841), Jubb (1965 and 1967), Smith and Smith (1966) and Skelton (1974a).

For all species the predominant background colours are olivaceous browns and greens which may vary from a light yellowish gold to deep olive or even steel-blue (as recorded by Skelton (1974a) for *O. quathlambae*). Ventral parts are usually lighter, either white or pale cream. The opercula are metallic silvery-gold with a red infusion as a result of the superficial presence of bloodvessels. The iris of the eye is golden and the pupil black. The fins are distinctive with the proximal portions becoming orange in juveniles and intensifying to bright scarlet in adults, especially males during the breeding season (spring and summer). The caudal fin is least affected by this red colouration but it can be fairly intensely coloured in certain individuals. The red colour impinges onto the adjacent body region in *O. quathlambae* to a greater extent than in the other species. The males of *B. erubescens* in breeding dress become suffused with red. The red colour of the fins persists in adults through the winter although to some extent the intensity fades at this time.

Certain markings on the body are broadly characteristic of the various species. These are represented diagrammatically in Fig. 32. *B. burchelli* juveniles, sub-adults and younger adults have irregular dark blotches on the dorso-lateral surface including a linear mid-lateral series which ends in the form of a large triangular mark at the base of the caudal fin. In older adults the pattern is obscured by a deepening of the general pigmentation. *B. burgi* is similar to *B. burchelli* although there is more frequently a tendency to form a single lateral band or connected series of blotches. In some populations (e.g. that of Verlorevlei) a series of thin wavy horizontal bands passes along the body below and more particularly above the lateral band.

Adult *B. phlegethon* are probably the most striking redfins having black blotches over the dorso-lateral surface and being silvery-white ventrally. The juveniles of this species have a prominent thin lateral stripe and lack the dark patches of the adults. *B. tenuis* is plain with a dark

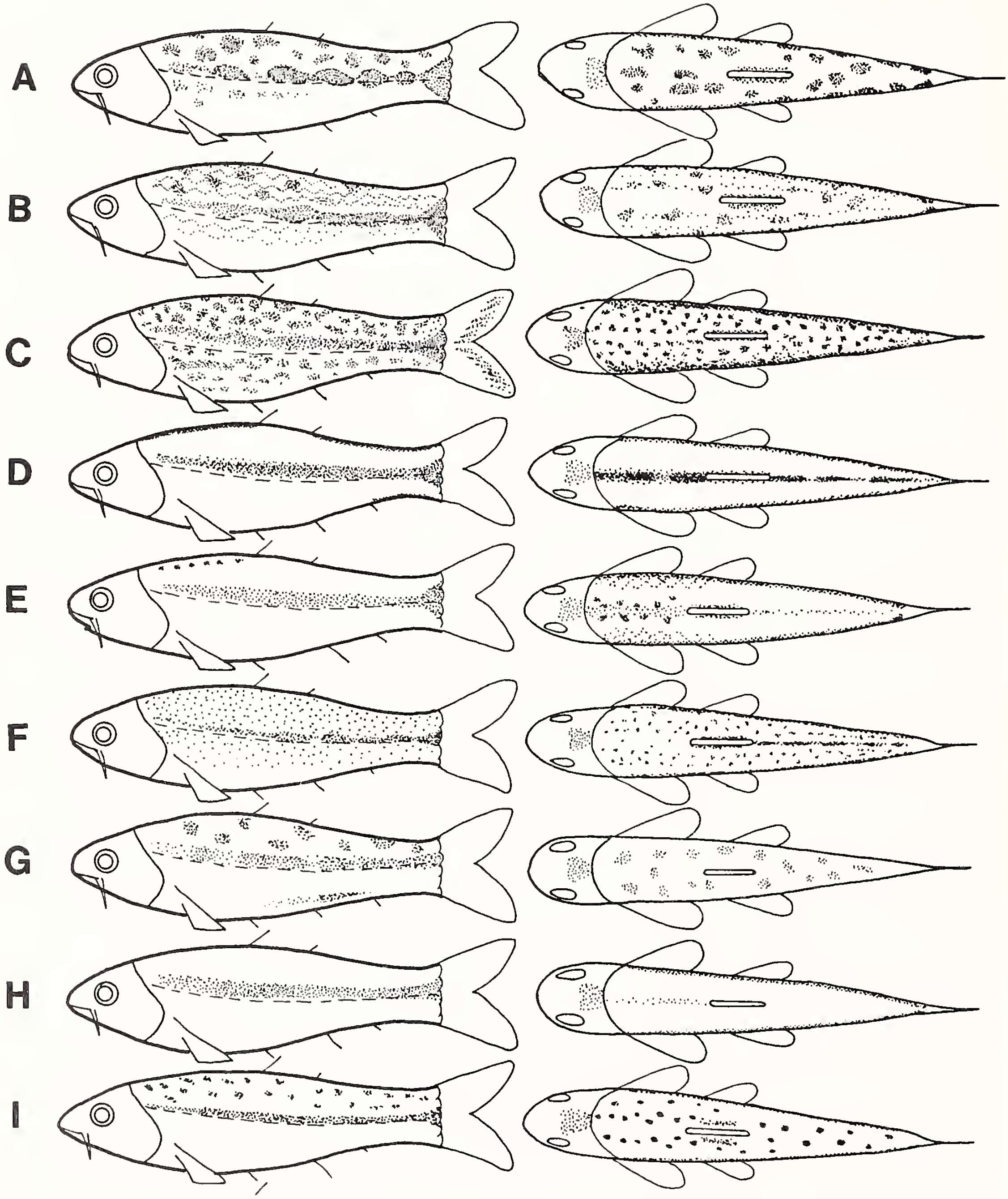

Fig. 32. Diagrammatic representation of pigmentation of redfin minnows. A. *B.2burchelli*, B. *B. burgi*, C. *B. phlegethon*, D. *B. tenuis*, E. *B. afer*, F. *B. asper*, G. *B. calidus*, H. *B. erubescens*, I. *O. quathlambae*.

mid-lateral band from behind the head to the base of the caudal fin, and a dark mid-dorsal stripe which is sometimes interrupted to form a series of dashes.

The individuals from most populations of *B. afer* have a mid-lateral body stripe that tends to expand at the base of the caudal fin and a bi-lateral series of predorsal spots. A mid-predorsal stripe is present in some populations. The dark waters of the Tsitsikama coastal rivers where *B. asper* (variant) occurs cause this species to be very dark itself but careful examination often shows the underlying pattern to be similar to that of *B. afer*. *B. asper* was described by Barnard (1943) as being like a "speckled hen" which is a result of the scale centres being darkly pigmented. There is often also an uneven or interrupted lateral stripe from the head to the base of the caudal fin in this species.

O. quathlambae usually has a dark lateral band and a bi-lateral series of discrete predorsal spots, dashes or vermiculations (Skelton, 1974a, and Gephard, 1978: Fig. 2).

The pigment patterns of *B. calidus* and *B. erubescens* are sufficiently distinct to be used to differentiate the two species (Skelton, 1974b). *B. calidus* has a broad broken lateral band and large irregular dark patches along the dorsal side. There is also a dark stripe along the base of the anal fin and usually a midventral stripe on the caudal peduncle. By way of contrast *B. erubescens* has only an unbroken lateral band from behind the head to the base of the caudal fin and a light mid-predorsal stripe.

Cephalic lateral line canals

The pattern of cephalic lateral line canals has not been used previously as a taxonomic character for southern African *Barbus* species. Although the overall pattern is similar for all the redfins there are differences in the degree of development between the two "serrated-rayed" and the "flexible-rayed" species (Fig. 33). In the former the canal system is continuous and a short median branch passes postero-dorsally from the supra-orbital canal. This branch is not present on the flexible-rayed redfins in addition to which the preopercular-mandibular canal is separate from the post-ocular commissure and the mandibular canal is reduced or absent. The mandibular canal is only developed as a short tube on the postero-lateral part of the dentary in *B. burchelli* and*B. burgi*. In *B. burgi* the connecting tube on the angulo-articular bone is frequently absent.

Osteological characters

A full description of the osteology of the redfin and other southern African *Barbus* species is being presented elsewhere (Skelton, in prep. b). The main differences are between the flexible- and the serrated-rayed groups which are considered to represent different phylogenetic lineages. A summary of the main points of comparison between the two groups is given in Table 10. Specific differences within these groups are summarised in Table 11 for the serrated-rayed species and Table 12 for the flexible-rayed species.

TAXONOMIC CONCLUSIONS

The outstanding problems in redfin taxonomy since Jubb (1967) concern the identity and limits of two pairs of closely similar species, *B. burchelli–B. burgi* and *B. afer–B. asper*. The recognition of each of these species depends on the taxonomic interpretation of certain morphological characteristics. A further problem concerns the taxonomic status of the group as a whole. Are the redfins monophyletic, and, if so, what is their generic status, or, if not, then what is the generic status of the different lineages? The phylogeny of the redfins will be

TABLE 10.

A comparative summary of aspects of osteology of redfin species.

	B. burchelli	*B. burgi*	*B. phlegethon*	*B. tenuis*
Neurocranium shape	moderately deep subrectangular	deep subrectangular	deep, narrow subrectangular	shallow, broad subrectangular
Supraethmoid	shallow groove	shallow groove	shallow groove	unossified, shallow groove
Lateral ethmoid, entopterygoidcondyles	concave	concave	concave	concave
Pterosphenoids	divided	divided	divided	divided
Supraorbitals	stout	stout	stout	reduced–irregular
Supraorbital shelf	wide notched	wide notched	wide notched	narrow–notched(?)
Infraorbitals				
(a) lachrymal	low peak	low peak	low peak	low peak
(b) dermosphenotic	triangular	broad-square	triangular	reduced-triangular
Exoccipitals	flanged	flanged	flanged	slender process
Intercalars	vestigial. irreg.	vestical. irreg.	vestical. irreg.	vestical. irreg.
Extrascapulars	irregular	irregular	irregular	irregular
Basioccipital process	flat; 30–40 °	flat; 30–40 °	flat; 30–40 °	flat; 30–40 °
Opercle	moderate	moderate	moderate	broad
Preopercular canal	complete	complete	reduced	reduced
Hyomandibular		narrow, tall	short, broad	
Metapterygoid (dorsal edge)	convex	convex	convex	convex, deep notched
Quadrate	shallow excav.	shallow escav.	shallow escav.	shallow escav.
Premaxilla	deep	deep	deep	deep
Maxilla	deep	deep	deep	deep
Lower jaw	short flange	short flange		
Urohyal	deep, tapered	deep, tapered	deep, tapered	slender, tapered
Pharyngeals	broad	broad	broad	broad
Pectoral girdle male vs female	dimorphic	dimorphic	dimorphic	dimorphic
Pelvic girdle				
Weberian neural crest	simple, irreg.	simple, irreg.	simple, irreg.	simple, irreg.
Supraneurals	absent (vestig.)	absent (vestig.)	absent (vestig.)	absent (vestig.)
Intramuscular bones	reduced	reduced	reduced	reduced
Dorsal fin (unbranched ray, pterygiophores)	slender (8)	slender (8)	slender (8)	slender (8)
Anal fin (pterygiophores)	6	6	6	6

TABLE 10.

A comparative summary of aspects of osteology of redfin species.

B. afer	*B. asper*	*B. calidus*	*B. erubescens*	*O. quathlambae*
moderate	moderate	moderate	moderate	moderate
subrectangular	subrectangular	subtriangular	subtriangular	subtriangular
shallow groove	shallow groove	deep groove	deep groove	unossified, shallow groove
concave	concave	condyles, not concave	condyles, not concave	concave
divided	divided	joined	joined	divided
stout (when present)	stout (when present)	slender	slender	vestigal irregular
wide notched	wide notched	narrow	narrow	wide notched
low peak	low peak	high peak	high peak	low peak
triangular	triangular	triangular variable	triangular variable?	
flanged	flanged	no process	no process	slender process
vest.(irreg.)	vestig(irreg.)	disc. well dev.	disc. well dev.	vestig (irreg.)
irregular	irregular	regular (?)	regular (?)	irregular
flat; 30–40°	flat; 30–40°	concave 50–60°	flat 30–40°	
moderate	moderate	suprapreopercular	suprapreopercular	broad
reduced	reduced	complete	complete	reduced
				short, broad
convex	convex	concave	concave	convex deep notched
shallow escav.	shallow escav.	deep excav.	deep excav.	shallow excav.
deep	deep	slender	slender	deep
deep	deep	slender	slender	deep
		long flange	long flange	
deep, tapered	deep, tapered	slender truncate	slender truncate	deep tapered
broad	broad	slender	slender	broad
dimorphic	dimorphic	monomorphic process short	monomorphic process long	dimorphic
simple.irreg.	simple.irreg.	flanged	flanged	simple irreg.
absent(vestig.)	absent(vestig.)	large	large	absent (vestig.)
reduced	reduced	well developed	well developed	reduced
slender (8)	slender (8)	stout serrated (8)	moderate (9)	slender (8)
6	6	7	8	6

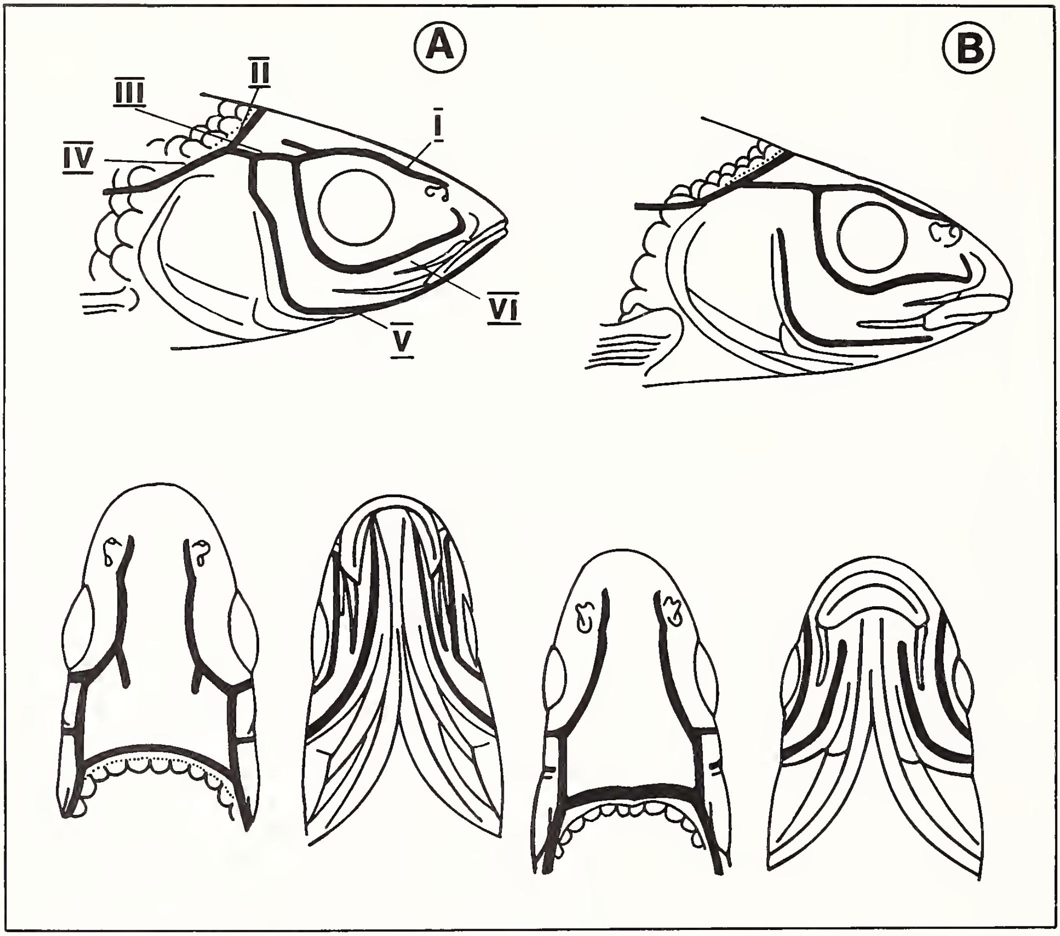

Fig. 33. Diagrammatic representation of the cephalic lateral line system of A. serrated-rayed redfins and B. flexible-rayed redfins. Canal nomenclature after Reno (1969): I. supraorbital canal, II. supratemporal canal, III. postocular commissure, IV. cephalic lateralis. V. preoperculo-mandibular canal.

addressed fully in a separate paper (Skelton, in prep. a). The specific and generic taxonomic status of the redfins is considered here in order to make the formal decisions necessary for the overall study. Before dealing with the specific taxonomic problems concerning the two species pairs mentioned above some comments on the taxonomy of the other redfin species are necessary.

As far as possible the material studied was drawn from across the geographic distribution range of each species. In the case of *O. quathlambae* little can be said on the geographic variation of the species. However, Gephard (1978) made a contribution in this regard showing that there

TABLE 11.

A summary of the main osteological differences between *B. calidus* and *B. erubescens*

Character	*B. calidus*	*B. erubescens*
Vomer	Extends beyond posterior region of lateral ethmoid.	Does not extend beyond posterior margin of lateral ethmoid.
Symplectic-Quadrate	Extends into relatively short groove. Symplectic shorter.	Extends into relatively long groove. Symplectic longer.
Opercle	less prominent dorsal process for dilatator operculi. Postero-lateral corner sharp.	More prominent dorsal process for dilatator operculi. Postero-lateral corner rounded.
Pelvic bone	Processes are short and broad.	Processes are more slender and elongate.

are a number of differences between specimens from the three, then known, populations of the species. The most divergent character measured by Gephard (1978) was body pigmentation (the other characters he considered were dorsal fin rays, anal fin rays, lateral line scales and anal fin pigmentation). Adopting Ginsberg's (1938) criteria, each population of *O. quathlambae* showed more than 90% divergence in pigmentation. The differences were nevertheless considered not worthy of taxonomic significance and, based on the the variation on scale counts, the populations were labelled as "varieties". These findings do suggest that each population has been relatively isolated from each other for some time.

Greenwood and Jubb (1967) described the unusual morphological characteristics of *O. quathlambae* in the African context and stated that these features indicated a refined degree of adaptation to a high mountain stream environment. Drakensberg mountain streams provide cold, clear, well-oxygenated waters, potentially fast currents, and shallow rocky substrates without extensive aquatic or marginal macrophytes. Colder temperatures are generally conducive to higher meristic characters in fishes (Barlow, 1961; Fowler, 1970) and this may have had an influence on the development of the vertebral and squamation characteristics of *O. quathlambae*. Gephard (1978) suggests that the species has crevice-spawning habits. Small scales and higher vertebral counts may therefore also be adaptations to enhance flexibility required for manoeuvering in confined spaces.

The reduction in the number of pharyngeal teeth to the extent of that found in *O. quathlambae* and *B. tenuis* is an extremely unusual development for African barbine species that suggests a strong selection pressure towards such reduction. In the general absence of interspecific piscine competition, it seems likely that this pressure has come from the available food source itself. In high altitude mountain streams phytogenous organic matter is usually limited (Allen, 1969) and the main source is autochthonous and allochthonous invertebrates. Benthic aquatic insects are the main food reported for *O. quathlambae* (Pike and Tedder, 1973, and Gephard, 1978). The sub-terminal mouth, short gut and form of the pharyngeal teeth are well suited for such food.

In spite of initial doubts on the validity of *B. tenuis* because of the *a priori* weakness or subsequent discreditation of Barnard's (1938 and 1943) diagnostic characteristics (body depth, absence of head tubercles, scale striae and squamation) the species proves to be soundly established. A slender profile and scales with more radiating striae than other redfin species are

TABLE 12.

A summary of osteological features of flexible-rayed redfin species.

Character	Description
Neurocranium shape	moderate—deep, subrectangular
Supraethmoid	poorly ossified, shallow groove
Lateral ethmoid condyles	concave
Pterosphenoids	divided
Supraorbitals	short & broad, reduced or vestigial in *B. tenuis* and *O. quathlambae*
Supraorbital shelf	broad, notched (narrow in *B. tenuis*)
Lachrymal	low dorsal peak
infraorbital 5	short, triangular (broad/squarish in *B. burgi*).
Exoccipitals	with flange, slender process in *B. tenuis* and *O. quathlambae*
Intercalars	vestigial, irregularly present
Extrascapulars	irregular
Basioccipital process	flat, 30–40 degrees
Opercle	moderately rectangular, shallow and broad in *B. tenuis* and *O. quathlambae*
Preopercular canal	complete, reduced in *B. phlegethon*, *B. tenuis* and *O. quathlambae*
Hyomandibular shape	moderate, narrow in *B. phlegethon*, short in *B. tenuis* and *O. quathlambae*
Metapterygoid (dorsal edge)	convex, notched in *B. tenuis* and *O. quathlambae*
Quadrate	shallow notch for symplectic
Premaxilla	relatively short and deep
Maxilla	relatively short and deep
Dentary	short flange for sensory canal present only in *B. burchelli* and *B. burgi*
Urohyal	relatively deep, mid-flange tapered
Pharyngeal bones	relatively broad
Pectoral girdle	sexually dimorphic
Weberian crest	simple, irregular
supraneurals	vestigial or absent
Intramuscular bones	reduced and weakly ossified
Dorsal fin ray	simple and flexible
Anal fin pterygiophores	6

reasonably consistent characteristics. The pharyngeal tooth formula is a strongly diagnostic character and the osteology of the species is also distinctive (Skelton, in prep. b). In the field *B. tenuis* may be recognised from the river bank by its characteristic mid-dorsal stripe (Skelton, pers. obs.). Collecting records and field observations indicate that *B. tenuis* favours smaller mountain tributaries rather than the lowland mainstreams of the Gourits system. Occasionally it occurs together with *B. asper* but this may be because of reduced environments from water abstraction for agricultural use.

Intraspecific variation in fin lengths and caudal peduncle proportions is recorded between the Gourits and Keurbooms River populations of *B. tenuis*. The Keurbooms population shows longer fins and a narrower caudal peduncle.

These differences are probably induced by differences in the environments of the two systems. The Keurbooms catchment has a mean annual precipitation of 750 to 900 mm (Midgeley and Pitman,1969) whereas comparable stream catchments of the Gourits receive from 400 to 500 mm. It is likely therefore that the flow regime of the Keurbooms is greater than the Gourits tributaries and the observed morphological differences are those which are known to respond in similar fashion in other cyprinids (e.g. Hubbs, 1940, Barlow, 1961, and Stewart, 1977).

Barbus phlegethon is the smallest redfin species and is characterised by distinctive pigmentation, a relatively deep and narrow body, a small mouth with very short barbels, and weakly developed secondary male sexual characters. It is restricted in distribution to a few tributaries of the Olifants mainstream and a single isolated population in the small Driehoek stream in the Cedarberg mountains (Fig. 34). There is a degree of geographical variation between populations of tributaries of the Olifants mainstream and the Driehoek population in the number of dorsal fin branched rays. Seven branched rays is the modal number for the dorsal fin of redfin species including *B. phlegethon* but six of ten specimens from the Driehoek population have only six branched rays. The Driehoek specimens also have a higher number of pectoral fin rays (mode 15 *vs* 13–14 from mainstream populations) and more lateral line scales (36–39 usually 37 or 38 *vs* 29–37 with a mode of 35 for mainstream populations). Several specimens in the Driehoek sample are larger than normally encountered for this species and one of these is a male with the best developed tubercles yet observed for this species.

The Driehoek stream differs from the mainstream valley tributaries of the Olifants River in factors such as altitude, gradient and physical dimensions. The altitude of the Driehoek is 900–1 200 m whereas the valley tributaries where *B. phlegethon* occurs are between 200–400 m. The Driehoek is a small stream (2–3 m wide and generally less than 0,5 m deep) with a low gradient and a sandy-gravel substratum whereas the valley tributaries are larger streams (5–10 m wide and up to 1,5 m deep), characterised by rocky pools and flowing stretches with a substratum of well-worn (i.e. smooth and rounded) loose rocks and pebbles. The Driehoek population may have been relatively isolated for some time and it is therefore possible that both genotypic and phenotypic factors are responsible for the observed morphological differences.

A summary of the main differences in external morphology and skeleton between *B. calidus* and *B. erubescens* is given in Table 13. The taxonomic significance of reduced serrations of the dorsal unbranched fin ray in *B. erubescens* was discussed by Skelton (1974b). It was concluded that the development or otherwise of such serrations is not a reliable taxonomic character for *Barbus* species. The intraspecific variation in this character can be large, for example, as described by Poll (1976) for a single population of *Barbus miolepis* Boulenger. The reason or reasons for such wide variation as well as the functional significance, if any, of a serrated spiny dorsal ray in *Barbus* species is not known, although speculative suggestions are possible.

Certain functionally linked characters may show a fine degree of correlation. In *B. erubescens*, for example, the relatively minor reduction in the number of pharyngeal teeth correlates with a difference in shape of the teeth, a more slender pharyngeal bone, and shorter length of gut compared with the same of *B. calidus*. Eastman and Underhill (1973) studied intraspecific variation in the pharyngeal teeth of 42 cyprinid species and concluded that the pharyngeal bones and tooth morphology are usually consistant and therefore taxonomically

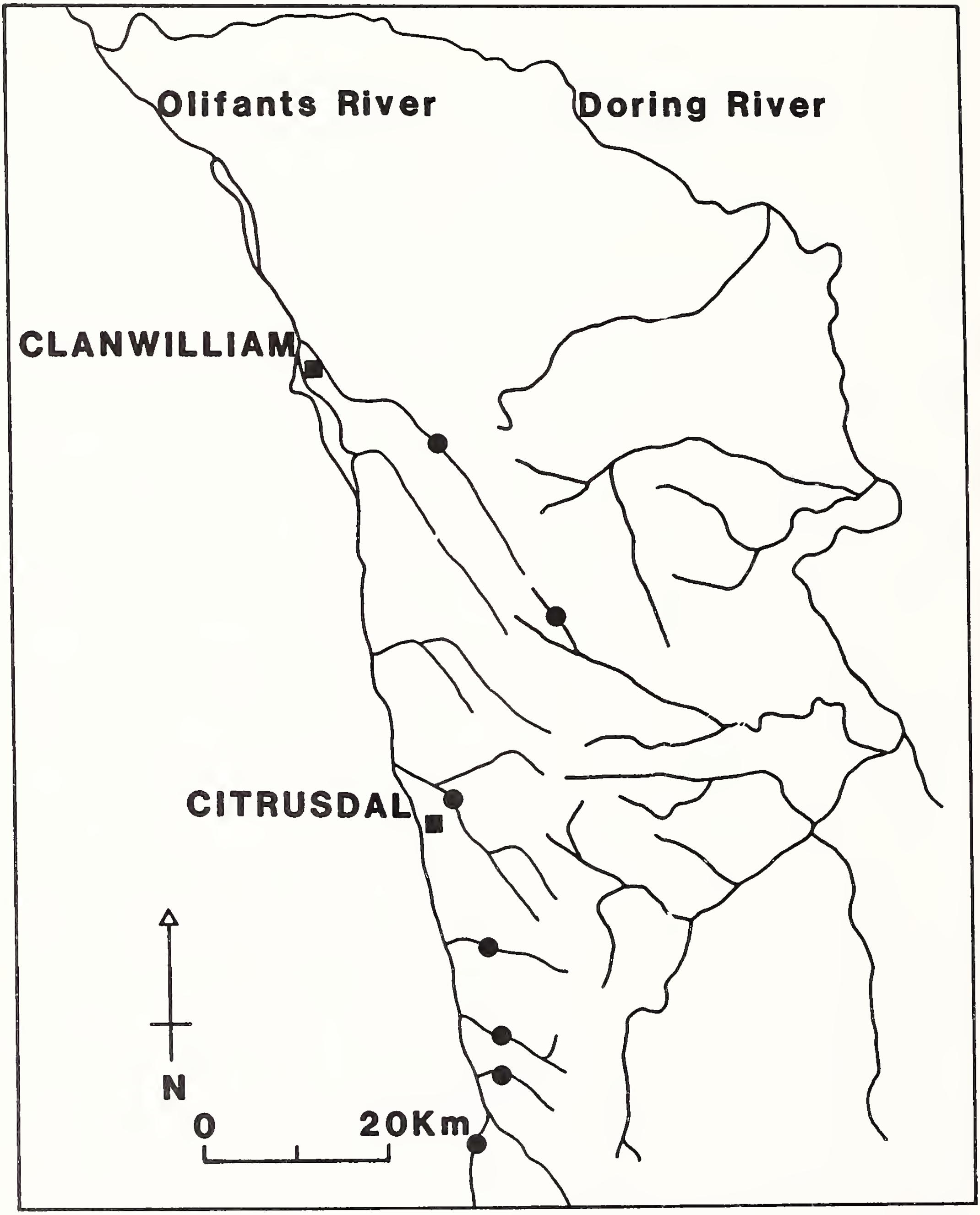

Fig. 34. Distribution of *B. phlegethon* in the Olifants River system.

TABLE 13.

A summary of certain character differences between *B. calidus* and *B. erubescens*

Character	*B. calidus*	*B. erubescens*
Orbit diameter (%HL) ($\overline{M}$)	29,1 (25–36)	26,75 (22–32)
Postorbit length (%HL) ($\overline{M}$)	43,6	46
Interorbit (%HL) ($\overline{M}$)	34,1	31,9
Caudal peduncle L.	19,5	21,1
Dorsal branched rays (mode)	7	8
Anal branched rays (mode)	6	7
Scale radii ($\overline{M}$)	9	13
Predorsal vertebrae (mode)	13	12
Pharyngeal bones L/W (+)	4,6	4,9
Pharyngeal teeth (mode)	2, 3, 5–5, 3, 2	2, 3, 4–4, 3, 2
Dorsal unbranched ray	strongly serrated	weak or no serrations
Pigmentation	broken lateral band, spotted dorsal surface	lateral stripe and plain dorsal surface
Symplectic bones	short injunction with quadrate, shallow	long injunction with quadrate, deep
Opercle	postero-ventral corner angular	postero-ventral corner rounded
Pelvic fin bones	ischial process broad, lateral prong short	ischial process slender, lateral prong long

useful for most species but tooth formulae are not always sufficiently consistent for this purpose. A similar conclusion is reached with respect to the pharyngeal teeth of the flexible-rayed redfins. For certain species, for example, *B. burgi*, *B. burchelli*, *B. asper* and *B. afer*, intraspecific variation in pharyngeal teeth and gut length is too broad to be a diagnostic taxonomic character at the species level. However, this broad variability is a character which sets these species apart from other similar-sized African barbines.

The use of barbels in cyprinid taxonomy is another feature which has stimulated much debate. Schmidt (1983) concluded that barbels are not sound generic characters and should be used with caution at the species level. The present study indicates clearly that each case should be judged on its own merits. It is necessary to examine comprehensive geographical and size-range series of a species before the taxonomic value of barbels is safely established. Barnard (1943) claimed the seemingly trivial difference in the development of the anterior barbels between *B. burchelli* and *B. burgi* indicated the real validity of the two species. This difference is consistent, however, and there are at least two other supporting characters, *viz.*, the size and shape of the last or 5th infraorbital bone and the size and number of head tubercles.

The 5th infraorbital is generally small and relatively slender in redfins and most other southern African *Barbus* species. Only in *B. burgi* does the bone develop wide flanges. Two examples of other cyprinids, in which a similar development of this bone has been used for taxonomic purposes, are given by Miller (1963) and Barbour and Miller (1978).

Head tubercles are frequently used for taxonomic purposes in cyprinid fishes. Tubercles serve a variety of functions in fishes and tubercles from different regions of the body may serve different purposes. Wiley and Collette (1970) and Collette (1977) suggested that the structures may have evolved to assist spawning individuals to maintain contact in flowing waters. Reid (1985) indicates that the large tubercles on the head and snout of *Labeo* species may have a hydrodynamic role. There is a clear sexual or secondary sexual function for the large head tubercles of redfin species because these develop fully only on adult males during the breeding season and are worn down as the season progresses (Barnard 1943, Cambray and Stuart 1985, and Skelton, pers. obs.). Cambray and Stuart (1985) suggest that the large head tubercles are used by male *B. burchelli* in defense of territories. Territoriality of tuberculated sexually mature males of other flexible-rayed redfin species (*B. phlegethon* and *O. quathlambae*) has been witnessed in the field (pers. obs.). The difference in tubercle development between *B. burgi* and *B. burchelli* is not an easy taxonomic character to use because it has to be gauged from comparable specimens in terms of size and state of sexual maturity and activity. There may be a degree of intraspecific variation in the development of tubercles which would negate their taxonomic value (e.g. tubercles have not yet been observed on any individual specimen of *B. burgi* collected in the Verlorevlei system). In spite of such limitations a difference in size and number of head tubercles of the mature males of *B. burgi* and *B. burchelli* is recorded here and supports the taxonomic distinction between these species whose status is therefore endorsed.

Further attention should be given to the taxonomic status of the Verlorevlei population of *B. burgi*. Specimens from this site display a distinctive colour and pigment pattern (a series of thin parallel longitudinal lines and no spots), have an exceptionally long intestine and have not yet been seen with head or body tubercles.

There are few examples in the literature of a cyprinid species having as large an intraspecific variation in gut length as that found for *B. burgi*. A reversed example is provided by Lachner and Wiley (1971) for a species of chub, *Nocomis leptocephalus*. Although this species usually has a long and whorled intestine certain populations have a short "S"-flexured gut. The authors attached no special taxonomic significance to these particular populations. The broad range of and interspecific overlap of the gut length in the flexible-rayed redfin species weakens the taxonomic value of this character at the specific level. In a group context, however, the broad variation is an unusual and therefore interesting taxonomic characteristic of these species.

The question of differences in scale counts between *B. afer* and *B. asper* has been discussed already. The conclusion reached was that *B. asper* is a distinctive small-scaled species confined to the larger tributaries and mainstreams of the Gourits and Groot-Gamtoos river systems and *B. afer* is a widespread polytypic species that includes populations from the south coastal rivers referred to as *B. asper* (variant). Pigmentation and gut length characters support this arrangement although neither are independently convincing taxonomic characters. A clinal variation in several morphometric characters also supports the taxonomic fusion of "typical" *B. afer* and *B. asper* (variant) into a single polytypic species.

The presence and distribution of *B. afer* and *B. asper* in the Gamtoos River system has always been a problem on account of their close similarity. Barnard (1943) considered that only *B. asper* was present in the Gamtoos but recognised that the form found in the mountain tributaries differed from the typical form in the Groot River tributary. Jubb (1965) mentioned that specimens from certain coastal tributaries of the system were closer to *B. afer* than to *B. asper*. As there was no clear distinction between the two species, museum samples were frequently confused.

The Groot River rises well beyond the fold mountain belt in the Great Karoo. It joins the Gamtoos mainstream after abruptly turning at right angles to its course and penetrating the

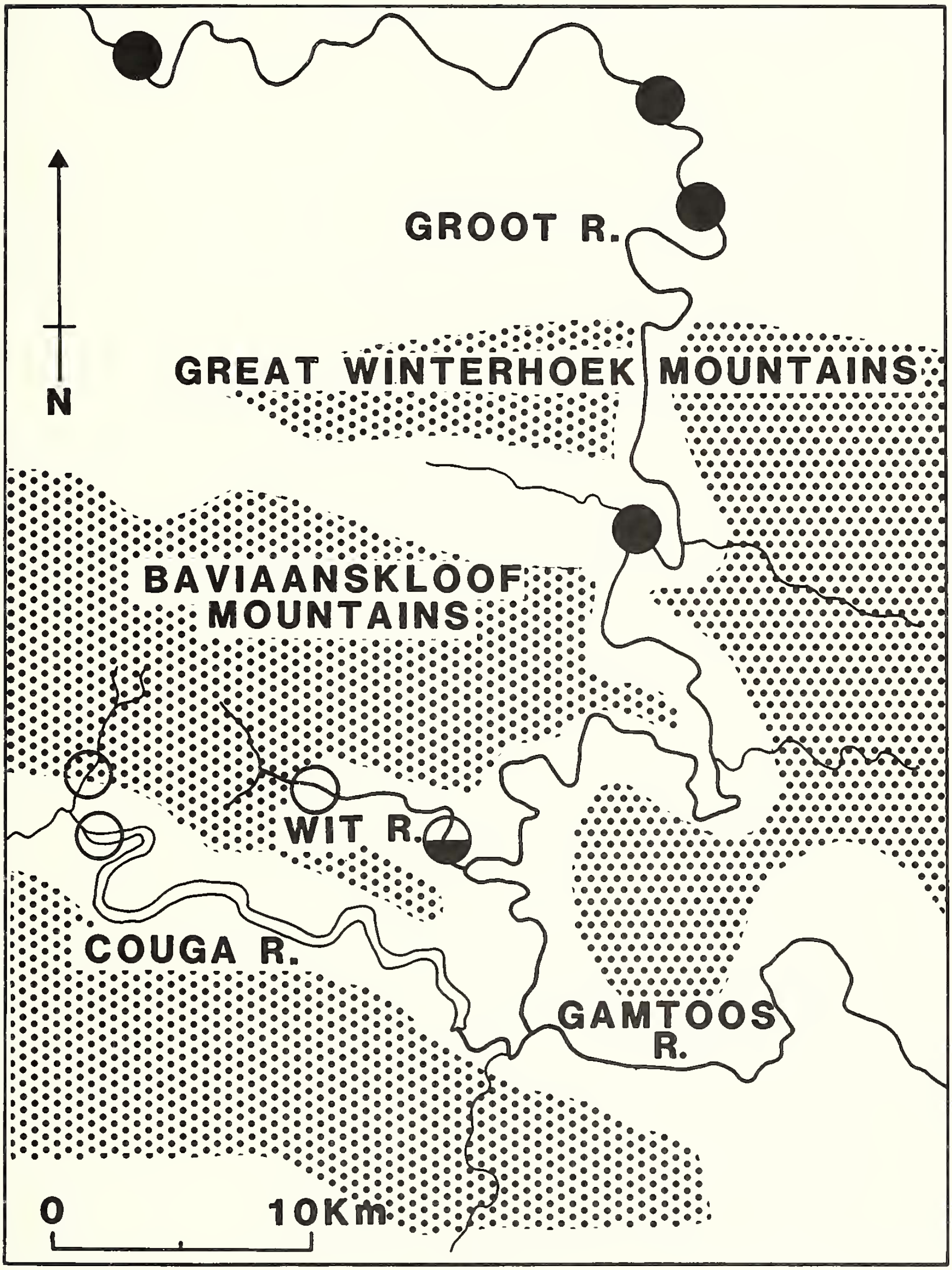

Fig. 35. Part of the Gamtoos River system showing the distribution of *B. afer* (unshaded circles) and *B. asper* (shaded circles). Site where both species collected given as half shaded circle.

Baviaanskloof-Great Winterhoek Mountains in a narrow gorge (Fig. 35). *Barbus asper* inhabits the Groot River to within the gorge whereas *B. afer* is found in the mountain tributaries of the system. Both species were collected in the lower reaches of the Wit River, a tributary that joins the Groot River within the gorge, but there is no evidence of integration of the two species at this site.

The Groot River drains Karoo sediments which impart high loads of total dissolved solids and sediments to the waters. Fold mountain tributaries are characteristically clear streams with low pH and dissolved mineral concentrations. The distribution of *B. asper* in the Groot and *B. afer* in the mountain tributaries appears to reflect distinctly different habitat preferences. This is supported by Hofmeyr's (1966) study which reported that *B. asper* was more tolerant of high chloride concentrations than *B. afer*.

The species-level taxonomic conclusions from this study may be summarised as follows: nine redfin species are recognised *viz.*, *B. burchelli* Smith 1841, *B. afer* Peters 1864, *B. asper* Boulenger 1911, *B. burgi* Boulenger 1911, *O. quathlambae* (Barnard 1938a), *B. phlegethon* Barnard 1938b, *B. tenuis* Barnard 1938b, *B. calidus* Barnard 1938b, and *B. erubescens* Skelton 1974. The interrelationships of the species will be given elsewhere (Skelton, in prep. a) but for the purpose of further discussion on their generic status it may be stated that the fairly obvious suite of differences between the two serrated-rayed species on the one hand (*B. calidus* and *B. erubescens*) and the flexible-rayed species on the other does reflect distinct phylogenetic origins of the two groups. Furthermore the phylogenetic investigation showed that, although very distinct in many ways, *O. quathlambae* is a member of the flexible-rayed monophyletic lineage. The only other formal taxonomic adjustment required is the inclusion of coastal populations of *B. asper* under *B. afer*.

GENERIC STATUS

All the redfins currently are referred to the unwieldly large genus *Barbus*. As far as reflecting phylogenetic relationships is concerned, this allocation is unrealistic and prejudicial to the classification of the species and the elucidation of their biogeography. The investigation on which the present paper is based (Skelton, 1980) also included a study of the phylogenetic relationships of the redfin species. This study showed clearly that two distinct lineages constitute the "redfins" *sensu lato*. The flexible-rayed redfin minnows form a monophyletic lineage of morphologically distinct species relative to all other *Barbus*. It is entirely in the interests of comparative biology to recognise this relationship, at least at the generic or sub-generic level. The genus traditionally embodies the concepts of relationship and distinctiveness (Bolin, 1947 and Mayr, 1969). Wiley (1981) considers a genus "a mandatory category to which every species must belong and which contains one species or a monophyletic group of species". With regard to placing the flexible-rayed redfins in a separate genus of their own there is no conflict with either the traditional or phylogenetic view of that category.

In the case of the redfins there is, however, an important practical difference to be overcome between the evolutionary and phylogenetic approaches. This concerns the generic placement of the species *Oreodaimon quathlambae* which currently commands its monospecific generic status on account of its distinctiveness (Greenwood and Jubb, 1967). In the phylogenetic system adopted here this morphological uniqueness is subsumed within the lineage at the level of common ancestry to the lineage (Wiley, 1981).

There is an available name within the genus group which under Articles 23 and 43 of the International Code of Zoological Nomenclature (3rd edition, 1985) must be used for the flexible-rayed redfin lineage. Andrew Smith (1841) included two species in the sub-genus *Pseudobarbus* (genus *Barbus*)—*B. (Pseudobarbus) burchelli* and *B. (Pseudobarbus) pallidus*. These two species were the first small cyprinids or minnows to be described from southern Africa. The definition of *Pseudobarbus* given by Smith (1841) included the character "intestinal canal long and contorted" which indicates that it was based on *B. burchelli* and not *B. pallidus* because a long coiled gut is a feature only of the former species. In any event there is no contention as to which is the type species of this genus because Jordan (1919) designated *B. burchelli* as the type species of *Pseudobarbus*. A redefinition of the genus *Pseudobarbus* to accommodate all the flexible-rayed redfins and exclude the species *B. pallidus* follows.

Pseudobarbus Smith 1841

Type species : *Pseudobarbus burchelli* Smith 1841, by subsequent designation, Jordan 1919.
Included species: *Pseudobarbus afer* (Peters 1864)
Pseudobarbus asper (Boulenger 1911)
Pseudobarbus burchelli Smith 1841
Pseudobarbus burgi (Boulenger 1911)
Pseudobarbus phlegethon (Barnard 1938)
Pseudobarbus quathlambae (Barnard 1938)
Pseudobarbus tenuis (Barnard 1938)

Diagnosis: Moderate sized (up to 150 mm SL) fusiform or terete cyprinid fishes; snout rounded; mouth sub-terminal or inferior and crescentic or sickle shaped; one or two pairs of simple circum-oral barbels; lips moderately developed sometimes thin and firm; pharyngeal teeth in two or three rows, 0–2, 3, 4–5 + 5–4, 3, 0–2; crowns of pharyngeal teeth variable with an oblique occluding surface with latero-terminal recurved tips (major cusps); intestine variable in length and degree of involution, from a simple single flexure with length sub-equal to SL, to multiple involutions with length up to 3,5 times the SL; peritoneum black. Scales moderately large to very small, radiately striated with radii present in all scale fields; scales on nape irregular and often crowded, reduced or embedded; breast scales reduced and embedded; no elongated trianguloid pelvic axillary scale. Lateral line interrupted or complete, straight or only slightly curved and runs mid-lateral along the caudal peduncle. Cephalic lateral line with preopercular canal not connected to postocular commissure, mandibular canal reduced or absent and supraorbital canal without branches. Adult fish have distinctive bright red patches on proximal half of fins and the adjacent body area. Mature males develop prominent conical tubercles on the snout and dorsal half of the head; small tubercles on the scale margins and bands of tubercles on the upper surface of the pectoral fin rays. Large females may develop tubercle buds or a few poorly developed tubercles on the head. Dorsal and anal fins with three or four simple flexible rays and invariably seven (dorsal) and five (anal) branched fin rays. From five to ten short, thick-set gill rakers on the lower limb (ceratobranchial) of leading gill arch. Total vertebrae 33–40. Supraneural bones absent or vestigial; frontals not overlapping lamellae of supraethmoid; intercalars reduced or absent; exoccipitals with or without a posterior flange; supraorbitals vestigial or short and accommodated in a recess on the supraorbital shelf of the frontal bones; four or five infraorbitals; lachrymal with low dorsal apex; premaxillae short and deep; urohyal with tapered horizontal flange. Pectoral fins sexually dimorphic being larger and more expanded in males;

pectoral girdle stouter in males than females; intramuscular bones vestigial and poorly ossified anterior to the dorsal fin.

SPECIES ACCOUNTS

Pseudobarbus burchelli Smith 1841

Neotype Fig. 36

Synonymy

Barbus (Pseudobarbus) burchelli Smith 1841, page unnumbered, pl XI no. 1. Type locality, "Various rivers of the Cape Colony"; Günther 1868, 96; Gilchrist and Thompson 1913, 417–418 (in part, 2 specimens from Robertson, Cape); Jubb 1965, 26–27, pl VIII; Jubb 1967, 97–99, Fig. 83, pl 14.

?*Barbus gobionides* Valenciennes in Cuvier and Valenciennes 1842, 189.

Gnathendalia vulnerata Castelnau 1861, 57.

Barbus multimaculatus Steindachner 1870, 11–12, Taf III Fig. 2.

Barbus vulneratus Boulenger 1905 b, 45; Boulenger 1911, 148–149 (in part, the 2 specimens from "Zonde Einde River"); Gilchrist and Thompson 1913, 415–416 (in part, Fig. 73 and the specimens from the Zonde Einde River); Barnard 1938 b, 83, Fig. 18 b and c.

Material examined.

Neotype: AMG/P 7223 A, male, 102 mm SL (Fig. 36) collected by S. C. Thorne, 13 December 1978 from the Tradouw River, Breë River system, south west Cape, 33° 56′ 50″ S, 20° 42′ 39″ E. (Under the International Code of Zoological Nomenclature, Art. 75 (f) this locality represents the type locality of the species.)

Other material: a—Breë River system: SAM 4693, Keisers R, Robertson, L. Keet; SAM 17621, Wit R, Bain's Kloof, E. F. Steer; SAM 17422, Tradouw R, K. H. Barnard, October 1925; SAM 18731, Genadendal, K. H. Barnard, January 1937; SAM 18750, Wit R, Bain's Kloof, L. Boonstra, March 1937; SAM 18751, Slanghoek R, K. H. Barnard, March 1937; SAM 18937,

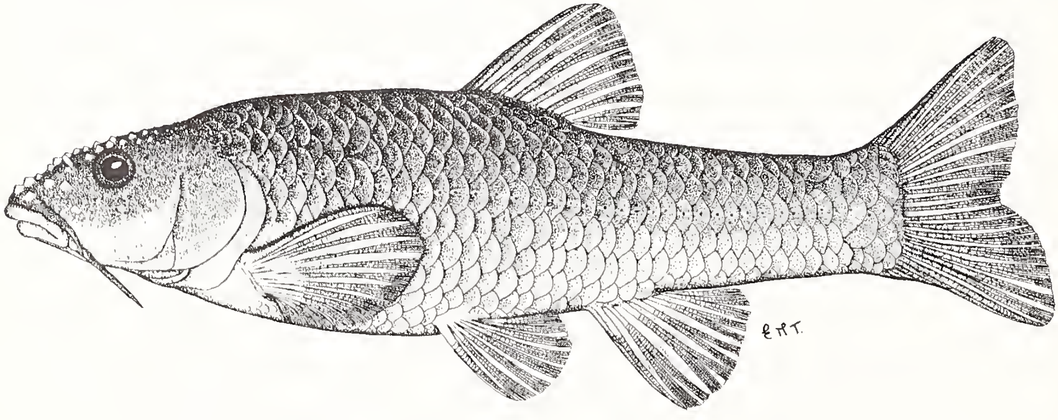

Fig. 36. *Pseudobarbus burchelli* Smith 1841, Neotype, AMG/P 7223A, male, 102 mm SL. Drawn by E. Tarr.

Sonderend R, H. G. Wood, September 1937; SAM 18987, Buffeljags R, K. H. Barnard, February 1938; SAM 22279, Hex R, A. C. Harrison; AMG/P 482, Wit R, Bain's Kloof, R. A. Jubb, November 1960; AMG/P 1411, Wit R, Bain's Kloof, F. L. Farquharson, April 1967; AMG/P 1566, Keisers R, K. H. van Rensburg, December 1967; AMG/P 1791, Keisers R, P. H. Skelton, October 1972; AMG/P 2031, Tradouw R, R. E. Stobbs, 1973; AMG/P 2077, Kabous R, P. H. Skelton, December 1973; AMG/P 2079, Klipplaas R, P. H. Skelton, December 1973; AMG/P 3463 and 3465, Wit R, Bain's Kloof, P. H. Skelton, October 1975; AMG/P 3840, Spreeudrifspruit, I. G. Gaigher, November 1976; AMG/P 4972, Keisers R, C. Stuart, September 1977; AMG/P 5475, Kogmanskloof R, C. Stuart, November 1977; AMG/P 5911–5915, Keisers R, W. C. N. Esterhuizen, 1977–1978; AMG/P 6028, Helderstroom, S. J. McVeigh, June 1978; AMG/P 7205 & 7220, Wit R, S. C. Thorne, February 1979; AMG/P 7223, Tradouw R, S. C. Thorne, December 1978; AMG/P 7224, Slang R, S. C. Thorne, December 1978; AMG/P 7443, Breë R, P. H. Skelton, November 1976; AMG/P 7444, Spreeudrifspruit, P. H. Skelton, November 1976.

b—Kaffirkuils River system: SAM 18988, Vette R, K. H. Barnard, February 1938; AMG/P 7393, Kruis R, S. C. Thorne, December 1978.

c—Duivenhoks River system: SAM 19345, C. K. H. Barnard, October 1938; AMG/P 3472, P. H. Skelton, October 1975; AMG/P 6138, S. C. Thorne, August 1978; AMG/P 7227, S. C. Thorne, December 1978.

d—Kars River: SAM 18979, K. H. Barnard, December 1937.

e—Grashoek River: SAM 18978, K. H. Barnard, December 1937.

f—Nieuwejaars River: SAM 18981, K. H. Barnard, December 1937.

Notes on the taxonomy

The precise identification of Smith's *B. burchelli* is open to debate because no type specimens are known to exist, the original description is entirely qualitative, the given illustration is inaccurate in diagnostic features (Barnard, 1943, and Greenwood and Crass, 1959) and the original locality was only given as "various rivers of the Cape Colony". The present allocation was determined by Jubb (1965) after P. H. Greenwood had examined the type skins of Castelnau's *Gnathendalia vulnerata* and concluded that they agreed with Smith's description of *B. burchelli*. Barnard (1943) previously showed that it was difficult (if at all possible) to determine whether Smith's *B. burchelli* was in fact the Berg River or the Breë River species. Jubb's decision on this species is accepted in the interests of taxonomic stability.

Günther (1868) placed *Gnathendalia vulnerata* in synonymy with *Barbus gobionides* Valenciennes in C and V 1842. Once again no types of the latter species exist and the description is totally inadequate to determine to which species it refers. Barnard (1943) declared the latter species name to be a *nomen dubium*. Boulenger (1905) placed Steindachner's *Barbus multimaculatus* in synonymy with *B. vulnerata* which is in turn now allocated to *P. burchelli*. The types of *B. multimaculatus* in the Natural History Museum of Vienna have been examined and the synonymy is confirmed.

The neotype of *P. burchelli* was selected from well-preserved recently collected material after it was reasonably established that no type(s) of this species have ever been referred to or are known to exist (P. H. Greenwood, pers. comm., and G. Swinney in litt. 1976).

Diagnosis

A redfinned cyprinid minnow reaching 136 mm SL with unbranched dorsal ray flexible, two pairs of well developed oral barbels each longer than the orbit diameter, breeding males with large conical tubercles on the head, from five to ten on either side of the snout. Intestine involuted up to 2,8 times the SL.

Description

Morphometric proportions and meristic data are given in Table 14. General shape fusiform with predorsal length slightly longer than postdorsal. Head length sub-equal to body depth. Eyes lateral to dorso-lateral. Mouth sub-terminal, protrusible and sickle shaped. Lips moderately developed or retracted from rim of lower jaw. Barbels simple and well developed, in adults both pairs are longer than the orbit diameter.

Scales radiately striate, focus central, radii in all fields. Breast scales are reduced and embedded, nape scales moderately crowded, axil scales of pelvic fin not prominent or elongate.

Paired fins are longer and wider in males, nearly reaching the anterior base of the pelvic fins. In females the shorter pectorals reach to within four or five scales of the pelvic bases. The pelvic fins are fan-shaped, nearly reaching the anterior base of the anal fin in males and to two or three

TABLE 14.

Morphometric and meristic measurements of *P. burchelli* (N=179)

Measurement	*Range*		
	Max.	Min.	$\overline{M}$
Standard length (mm)	136,0	28,0	54,3
Head length (%SL)	33,1	24,7	27,0
Head depth (%HL)	76,8	62,2	69,9
Snout length (%HL)	41,5	30,6	36,0
Orbit diameter (%HL)	36,7	17,8	28,5
Postorbit length (%HL)	50,7	38,5	45,2
Interorbit length (%HL)	36,5	24,1	30,6
Predorsal length (%SL)	55,2	48,9	51,3
Postdorsal length (%SL)	51,4	44,9	48,8
Dorsal fin base (%SL)	15,6	11,2	13,4
Dorsal fin length (%SL)	26,6	19,0	23,2
Pectoral fin length (%SL)	25,0	18,6	21,7
Pelvic fin length (%SL)	19,2	14,0	16,6
Anal fin length (%SL)	25,0	17,3	20,3
Anal fin base (%SL)	13,5	7,1	10,7
Body depth (%SL)	29,3	22,8	25,5
Body width (%SL)	21,8	13,7	16,8
Caudal peduncle length (%SL)	28,0	21,3	24,8
Caudal peduncle depth (%SL)	17,7	10,9	12,3
Anterior barbel length (%OD)	115,0	3,7	55,2
Posterior barbel length (%OD)	166,0	3,7	94,7
Pectoral–pelvic length (%SL)	27,6	21,1	24,6
Pelvic–anal length (%SL)	17,1	11,9	14,3
Pharyngeal bones L/W (N = 120)	4,5	3,0	3,5
Length of intestine (%SL) (N = 140)	280,5	73,4	159,2

Meristics	
Dorsal fin rays	iii–iv (iv) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 4–6 (5)
Pectoral fin rays	12–16 (14)
Pelvic fin rays	7–9 (8)
Total vertebrae	34–38 (36–37)
Precaudal vertebrae	17–20 (18–19)
Caudal vertebrae	15–20 (17–18)
Predorsal vertebrae	11–13 (12)
Preanal vertebrae	18–22 (19–20)
Lateral line scales	29–39 (36)
Caudal peduncle scale rows	12–18 (12)
Scale rows lat. line –dorsal	5–7 (6)
Scale rows lat. line –pelvic	4–6 (4)
Scale rows lat. line –anal	4–6 (4)
Predorsal scale rows	14–22 (17–19)
Primary scale radii ($\overline{M}$ to nearest whole no.)	10
Pharyngeal teeth (mode)	2, 3, 5–5, 3, 2

scales before this fin in females. The posterior edge of the dorsal and anal fins is straight or gently rounded. The anterior base of the dorsal fin lies just posterior to the origin of the pelvic fins. The caudal fin is forked with rounded lobes.

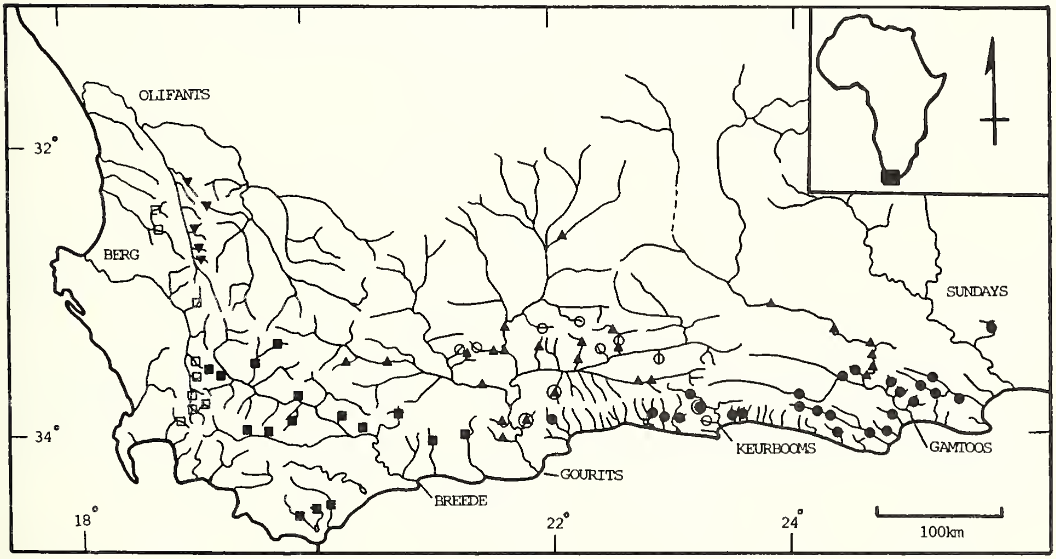

Fig. 37 A. Distribution of *Pseudobarbus* species in Cape coastal river systems based on museum records referred to in this study. Symbols may include multiple collection records. Unshaded square—*P. burgi*, shaded square—*P. burchelli*, inverted shaded triangle—*P. phlegethon*, shaded triangle *P. asper*, unshaded circle—*P. tenuis*, shaded circle—*P. afer*.

There are 2–3 + 6–9 short gill rakers on the leading arch. The pharyngeal bones are falcate with three rows of teeth in the formula 2, 3, 5–5, 3, 2. Pharyngeal teeth have obliquely truncate crowns which are closely applied to each other to form a grinding occlusal surface. The intestine is involuted with two or three secondary coils and extends up to 2,8 times the SL.

Mature sexually active males develop large conical tubercles on the top of the head and the snout. At full development the pattern includes bilateral groups of five to ten tubercles on the snout, single arcs above the nares and orbits and scattered tubercles on the head dorsum. Bands of small tubercles from five to six deep develop over the branched pectoral fin rays. Single tubercle rows occur on the rays of other fins. A single row of minute tubercles forms along the free edge of body scales. Large mature and sexually active females develop tubercle buds on the head.

Colour variable, from light to dark olive green or brown in juveniles becoming darker in adults. Juveniles with large dark blotches along the flanks and over the dorsal half of the body including a mid-lateral series of irregular spots with a large sub-triangular mark at the end of the caudal peduncle. Basal half of fins scarlet in mature fishes, fin rays dark brown, the membranes hyaline distally.

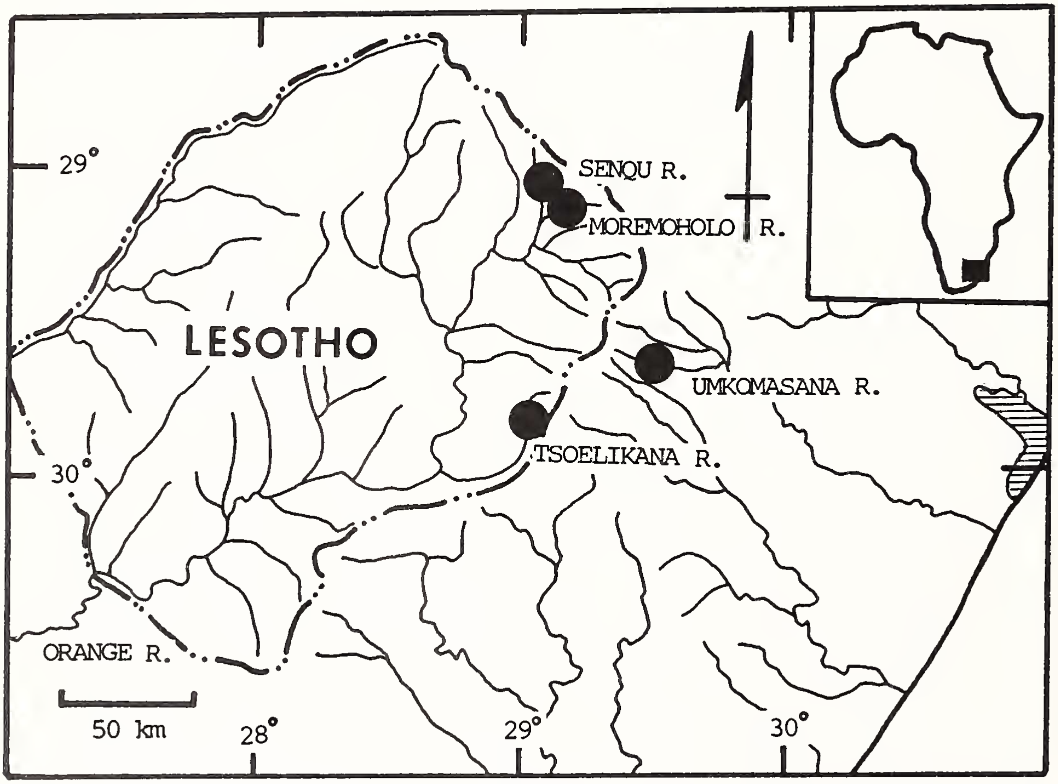

Fig. 37 B. The distribution of *P. quathlambae* in tributaries of the Orange (Senqu) River in Lesotho and the Umkomazana River in Natal, based on museum records referred to in this study. Symbols may include multiple collection records.

The lateral line is complete or semi-complete, and passes more-or-less mid-laterally along body and caudal peduncle. Cephalic lateral line with a disjunct preopercular-mandibular canal which is reduced from the anterior end of the mandible.

Distribution

P. burchelli is found throughout the Cape Fold Mountains reaches of the Breë River system as well as the adjacent Kars, Nieuwejaars and Sout river systems to the west and the Duivenhoks and Kaffirkuils rivers to the east (Fig. 37A). In a recent study Cambray and Stuart (1985) found that the species was virtually absent from the mainstream of the Breë River and tended to exist only in tributaries of the system.

Conservation status

Burchell's redfin is included in the South African Red Data Book—Fishes as a rare species (Skelton, 1987).

Etymology

The species was named for the naturalist and early explorer-traveller in South Africa, William Burchell.

Pseudobarbus burgi (Boulenger 1911)

Fig. 38.

Synonymy

Barbus anoplus (*non* Weber 1897, 152 (in part, the specimen from Frenchhoek).

Barbus burchelli: Boulenger 1911, 164, Fig. 122 (in part, the Eerste River specimens); Gilchrist and Thompson 1917, 417–418, Fig. 75 (in part, the Eerste River and Berg River specimens); Barnard 1938 b, 82–83; Barnard 1943, 185–188, Fig. 18a.

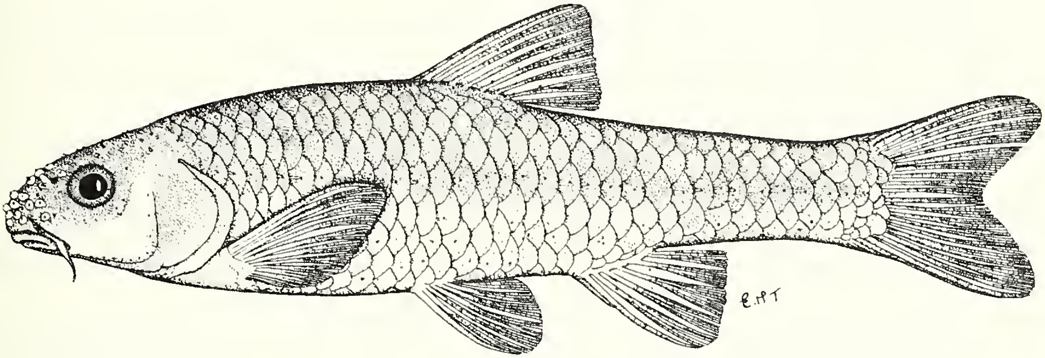

Fig. 38. *Pseudobarbus burgi* (Boulenger 1911), AMG/P 6156, male, 85 mm SL, Drawn by E. Tarr.

Barbus burgi Boulenger 1911, 147–148, Fig. 124. Type locality "Burg (*sic*) River, Paarl division"; Gilchrist and Thompson 1917, 419, Fig. 76; non Pellegrin 1936, 55.
Barbus afer (*non* Peters 1864); Boulenger 1911, 178–179.
Barbus bergi: Jubb 1965, 27–28, Fig. 9 (unjustified emendation); Jubb 1967, 99, Fig. 84.

Material examined

Lectotype: BMNH 1901.2.11.14, 72 mm SL, collected by Mr Brown from the Berg River, Paarl division. Paralectotypes: BMNH 1901.2.11.15–16, 67 mm and 61 mm SL, collected with the holotype.

Other material: a—Berg River system : SAM 4696, Paarl, Mr Brown; SAM 18094, Groot Drakenstein, A. C. Harrison, 1930; SAM 18608, Lemiet R, K. H. Barnard, 1936; SAM 18747, Groot Drakenstein, K. H. Barnard, 1937; SAM 19027, Bushmans R, K. H. Barnard, September 1938; SAM 18935, Twentyfour R, K. H. Barnard, August 1937; AMG/P 1578, 1579, Krom R, C. M. Gaigher, February 1971; AMG/P 2076, Krom R, P. H. Skelton, December 1973; AMG/P 4041, Wemmershoek, P. H. Skelton, June 1977; AMG/P 6144, 6148, Franschoek R, S. C. Thorne, November 1978; AMG/P 6153, 6156, Wemmershoek, S. C. Thorne, November 1978; AMG/P 6170, Wemmers R, S. C. Thorne, November 1978; AMG/P 7211, Boesmans R, S. C. Thorne, February 1979.

b—Eerste River: SAM 4695, Peringuey; SAM 5090, Dr Kruger; SAM 22746, Stellenbosch dam, A. C. Harrison; TM 8348 (779), Stellenbosch dam, Dr van der Horst, Oct 1930; BMNH 1901.2.11.11–13, Eerste R, at Stellenbosch, donated by the SAM.

c—Verlorevlei River: AMG/P 1874, Berg Valley stream, P. H. Skelton, February 1973; AMG/P 1875, Kruis R, P. H. Skelton, February 1973.

Notes on the taxonomy

The close similarity between *P. burgi* and *P. burchelli* and the confusion in the identity of the latter species has affected the nomenclatural history of both species. Barnard (1938b) placed *B. burgi* as a junior synonym of *B. burchelli* recognising the Breë River species as *B. vulneratus*. Jubb (1965) switched the arrangement by naming the Breë River species as *B. burchelli* with *B. vulneratus* as its junior synonym and calling the Berg River species *B. burgi* (his emendation of the spelling to *bergi* is unjustified and hence rejected here). Although, in the author's opinion, the evidence for this switch is equivocal, and therefore is dubiously justified (see taxonomic history above), to reverse the decision at this stage would simply cause further confusion and is equally unjustified.

The specimen from the Okavango River identified as *B. burgi* by Pellegrin (1936) is not of this species (Skelton, pers. obs.) (*vide* Barnard, 1943).

The lectotype was chosen from the syntype series of three specimens on the basis of size and condition. The specimens of the type series were originally derived from a sample in the SAM (SAM 4696).

Diagnosis

Unbranched dorsal ray is slender and flexible; two pairs of simple oral barbels, the anterior pair is short and is only present in specimens above 40 mm SL (i.e. adults and sub-adults); pharyngeal teeth with truncate oblique crowns; intestine involuted but variable, up to 3,6 times the SL; mature males with large conical tubercles on the head, at full development there are from 10 to 15 clustered on either side of the snout. Most similar to *P. burchelli* from which it is distinguished by having slightly larger scales (30–35 *vs* 32–37 in the lateral line), shorter anterior barbels, a slightly more anterior placement of the dorsal fin, the smaller more numerous tubercles on the head, and a more expansive 5th infraorbital.

Description

Morphometric and meristic data are given in Table 15. A medium sized (reaches 109 mm SL) fusiform cyprinid minnow. Head deep with rounded anterior profile, its length sub-equal to the depth of the body. Eyes lateral. Mouth sickle-shaped, inferior and protrusible, with moderate lips and two pairs of simple barbels.

Body with radiately striated scales, radii from central focus in all of the scale fields. Breast scales reduced and embedded, isthmus area naked. There are no elongated pelvic axillary scales.

The dorsal fin originates above the pelvics, the posterior edge of dorsal and anal fins more-or-less straight; the caudal fin is forked with rounded lobes. The paired fins are sexually

TABLE 15.

Morphometric and meristic measurements of *P. burgi* (N=107)

Measurement		*Range*		
		Max.	Min.	$\overline{M}$
Standard length (mm)		109,0	34,0	59,4
Head length (%SL)		29,4	22,9	25,9
Head depth (%HL)		80,8	64,0	73,8
Snout length (%HL)		42,1	30,0	35,6
Orbit diameter (%HL)		37,5	22,3	29,1
Postorbit length (%HL)		53,0	38,7	47,1
Interorbit length (%HL)		40,0	27,8	33,5
Predorsal length (%SL)		53,8	44,6	48,9
Postdorsal length (%SL)		55,4	46,3	51,1
Dorsal fin base (%SL)		15,4	11,7	13,7
Dorsal fin length (%SL)		28,4	16,1	24,5
Pectoral fin length (%SL)		26,4	14,7	21,5
Pelvic fin length (%SL)		20,7	7,9	17,9
Anal fin length (%SL)		23,4	14,0	20,1
Anal fin base (%SL)		12,4	8,5	10,3
Body depth (%SL)		32,0	20,9	27,4
Body width (%SL)		18,6	9,8	15,2
Caudal peduncle length (%SL)		38,3	20,9	25,0
Caudal peduncle depth (%SL)		3,3	9,1	11,8
Anterior barbel length (%OD)		80,0	2,8	18,7
Posterior barbel length (%OD)		47,3	21,9	71,2
Pectoral–pelvic length (%SL)		32,0	16,5	24,7
Pelvic–anal length (%SL)		21,1	13,0	15,8
Pharyngeal bones L/W	(N = 58)	4,2	2,7	3,3
Length of intestine	(N = 81)	360,6	116,9	231,7

Meristics	
Dorsal fin rays	iii–iv (iii) + 6–8 (7)
Anal fin rays	ii–iv (iii) + 5–6 (5)
Pectoral fin rays	13–18 (14–15)
Pelvic fin rays	7–9 (8)
Total vertebrae	35–39 (36–37)
Precaudal vertebrae	17–20 (19)
Caudal vertebrae	16–20 (18)
Predorsal vertebrae	10–12 (11–12)
Preanal vertebrae	19–21 (20)
Lateral line scales	28–37 (30–34)
Caudal peduncle scale rows	12–16 (12)
Scale rows lat. line –dorsa	4–6 (5)
Scale rows lat. line –pelvic	3–5 (4)
Scale rows lat. line –anal	3–5 (4)
Predorsal scale rows	12–18 (15)
Primary scale radii ($\overline{M}$ to nearest whole no.)	8
Pharyngeal teeth (mode)	2, 3, 5–5, 3, 2

dimorphic with males having larger more expansive and rounded pectorals and pelvics than the females.

The gill rakers are short and stubby with 2–4 + 6–10 on the leading arch. Pharyngeal bones are falcate with teeth in 3 rows in the formula 2, 3, 5–5, 3, 2. Pharyngeal teeth have obliquely truncate closely applied crowns that present a grinding-type occlusal surface. The intestine is involuted with two or three secondary coils and extends up to 3,5 times the SL in adults from certain populations.

Conspicuous conical tubercles develop on the head of sexually active males. The pattern of these tubercles is similar to that of *P. burchelli* but the tubercles are relatively smaller and more numerous in relation to those of the latter species. There can be from 10–15 tubercles in separate bi-lateral clusters on the snout. Tubercle bands with three or four tubercles across overlie the pectoral fin branched rays. Single rows of tubercles occur on the rays of the other fins. A single arc of tubercles occurs along the free edge of each scale in all but the most ventral (belly) region of the body. Large females develop a few tubercle buds on the head.

Colour varies with habitat from light brown to dark olive, flanks may be silvery with ventral parts light greyish cream. Fins hyaline in juveniles becoming scarlet red over basal part in adults. A dark irregular lateral band that ends in the form of a sub-triangular mark at the base of the caudal fin is more prominent in juveniles. Fine parallel longitudinal lines above the lateral band are also variously present in preserved specimens. The iris is silvery golden, the operculum iridescent golden.

The lateral line passes straight along the body and is complete or semi-complete. The cephalic lateral line system has a disjunct preopercular-mandibular canal and the mandibular portion is reduced from the anterior end to form a short canal which just reaches the dentary bone. The 5th infraorbital bone is relatively well developed with broad flanges.

Distribution

Pseudobarbus burgi occurs in the Verlorevlei River system, the Great Berg River system and formerly in the Eerste River (last known record in 1930, however, Barnard (1943) stated that the species was still present in the system at that time) (Fig. 37A). The range of the species has been severely reduced in the Great Berg River system over the past few decades and the species is now restricted to a few small tributaries.

Conservation status

The Berg River redfin is an endangered species (Skelton, 1987).

Etymology

This species was named for the Great Berg River, south west Cape.

Pseudobarbus phlegethon (Barnard 1938)

Fig. 39.

Synonymy

Barbus phlegethon Barnard 1938 b, 87–88. Type locality "Olifants River, Clanwilliam, Cape"; Barnard 1943, 204–206, Fig. 20; Jubb 1965, 32, Fig. 13; Jubb 1967, 97, Fig. 82.

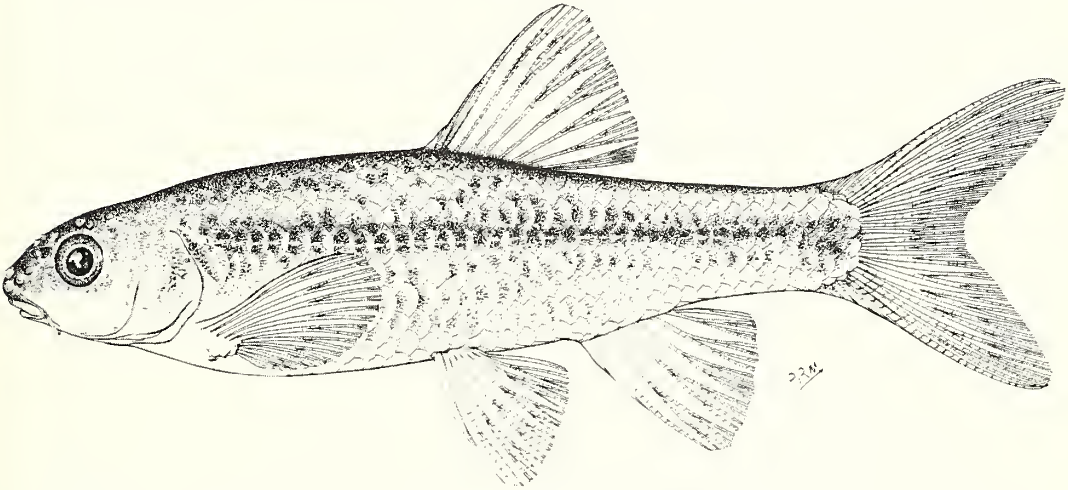

Fig. 39. *Pseudobarbus phlegethon* (Barnard 1938), AMG/P 8203, male, 50 mm SL. Drawn by P. Meakin.

Material examined

Lectotype: SAM 22484, male, 43 mm SL; 32 paralectotypes SAM 22484 (this is a composite sample derived from SAM 18767 and SAM 19003, see taxonomic notes); 25 paralectotypes SAM 18767 Boontjies River, Olifants River system, K. H. Barnard, April 1937; 29 paralectotypes SAM 19003 Boontjies River, Olifants River system, K. H. Barnard, April 1938.

Other material: all Olifants River system : SAM 22479, Thee R, K. H. Barnard; SAM 22483, K. H. Barnard, February 1939; AMG/P 722, Thee R, K. van Rensburg, January 1964; AMG/P 1394, Keerom, K. van Rensburg, January 1964; AMG/P 1399, Noordhoeks R, F. L.

Farquharson, April 1967; AMG/P 1820 and 1821, Thee R, D. Heard, September 1972; AMG/P 1852, Jan Diessels R, P. H. Skelton, January 1973; AMG/P 1863, Noordhoeks R, P. H. Skelton, February 1973; AMG/P 1868, Thee R, P. H. Skelton, February 1973; AMG/P 1880, Noordhoeks R, K. van Rensburg, March 1965; AMG/P 2053, Noordhoeks R, P. H. Skelton, October 1973; AMG/P 2054, Driehoek R, P. H. Skelton, October 1973; AMG/P 7366, Driehoek R, P. H. Skelton, December 1978.

Notes on the taxonomy

Dr K. H. Barnard was not meticulous in designating or labelling type material and consequently there is sometimes doubt as to what constitutes the type material of the species he described. In the absence of information to the contrary the author regards the type material of Barnard's species as that material known to have been available to him before the publication of the species description. In the case of *P. phlegethon* the samples concerned are SAM 18767 and SAM 19003 which were combined at some time prior to the present revision, labelled as syntypes and given the new accession number SAM 22484 (Dr P. A. Hulley SAM, in litt., November 1979). The lectotype was selected from this series on the basis of size and condition.

Diagnosis

A moderately small cyprinid (maximum size recorded 71 mm SL), with a small inferior mouth and a single pair of short oral barbels. The pigmentation is a striking combination of black blotches on a lighter brown and silvery white background. The species is not easily confused with other cyprinid species in the Olifants system on account of its small mouth and short single pair of barbels. There are five branched rays in the anal fin.

Description

The morphometric and meristic data for this species are given in Table 16. The general shape is fusiform with head length sub-equal to the bodydepth. The head is compressed with an ovoid lateral profile. The eyes are lateral. The mouth is sub-terminal, protrusible and sickle-shaped. The lips are moderately well developed or retracted from the rim of the mandible. The gill openings are attached at the isthmus. There is a single pair of short barbels at the angle of the mouth.

The body is moderately compressed, the length of the caudal peduncle is greater than twice the depth. Scales are cycloid with radiate striae in all fields. Breast scales are reduced in size and embedded and there are no triangular scales in the axils of the pelvic fins.

The paired fins are dimorphic in the sexes with mature males having longer, more rounded and expansive pectorals and pelvic fins than the females. The pectorals almost reach the base of the pelvics in the males and their pelvics reach the base of the anal. The hind edge of the dorsal and anal fins is nearly straight or slightly concave. The caudal fin is forked with pointed lobes. The dorsal fin originates above or just behind the origin of the pelvic fins.

There are 2 + 4–6 short, blunt gill rakers on the leading arch. The pharyngeal bones are falcate with a length to width ratio of 2,9–3,9. The pharyngeal teeth occur in three rows, 1, 3, 5–5, 3, 1. The crowns of the pharyngeal teeth are obliquely truncate. The intestine is involuted and up to 2,5 times the SL.

Mature breeding males have few small conical tubercles on the snout and on top of the head. There are bands of minute tubercles over the pectoral branched fin rays. Tubercles have not been observed on the scales of this species.

Table 16.

Morphometric and meristic measurements of *P. phlegethon* (N=92)

Measurement		*Range*		
		Max.	Min.	$\overline{M}$
Standard length (mm)		59,5	27,5	43,3
Head length (%SL)		28,7	23,9	25,6
Head depth (%HL)		82,4	66,9	75,0
Snout length (%HL)		41,2	31,1	35,2
Orbit diameter (%HL)		36,3	25,3	30,2
Postorbit length (%HL)		57,1	43,1	46,4
Interorbit length (%HL)		38,8	27,2	32,8
Predorsal length (%SL)		55,2	49,0	52,4
Postdorsal length (%SL)		51,0	44,8	47,6
Dorsal fin base (%SL)		15,2	10,9	13,3
Dorsal fin length (%SL)		27,6	19,2	24,0
Pectoral fin length (%SL)		25,3	17,8	20,9
Pelvic fin length (%SL)		20,8	15,4	17,3
Anal fin length (%SL)		23,7	17,0	21,2
Anal fin base (%SL)		12,1	9,1	10,1
Body depth (%SL)		27,8	21,4	24,2
Body width (%SL)		17,6	11,7	14,4
Caudal peduncle length (%SL)		26,9	21,4	23,9
Caudal peduncle depth (%SL)		12,1	9,1	10,8
Anterior barbel length (%OD)		—	—	—
Posterior barbel length (%OD)		50,0	2,6	26,9
Pectoral–pelvic length (%SL)		31,9	23,3	27,4
Pelvic–anal length (%SL)		18,9	12,0	14,7
Pharyngeal bones L/W	(N = 63)	3,9	2,9	3,4
Length of intestine (% SL)	(N = 77)	244,0	78,1	142,4

Meristics	
Dorsal fin rays	iii–iv (iii) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 5–6 (5)
Pectoral fin rays	11–15 (13–14)
Pelvic fin rays	7–9 (8)
Total Vertebrae	35–37 (36)
Precaudal vertebrae	17–19 (18)
Caudal vertebrae	16–19 (17–18)
Predorsal vertebrae	11–14 (12–13)
Preanal vertebrae	18–21 (20)
Lateral line scales	29–37 (35)
Caudal peduncle scale rows	10–14 (12)
Scale rows lat. line–dorsal	4–6 (5)
Scale rows lat. line–pelvic	3–4 (4)

Meristics	
Scale rows lat. line–anal	3–5 (3–4)
Predorsal scale rows	14–20 (16–17)
Primary scale radii ($\overline{M}$ to nearest whole no.)	12
Pharyngeal teeth (mode)	1, 3, 5–5, 3, 1

Small fry and juveniles of the species have a single dark lateral stripe from behind the head to the base of the caudal fin. Adult specimens are heavily blotched with irregular black spots on the body apart from the ventral belly region. The background colour is a light brown with silvery-white lower flanks and belly. The head is darker above and light below with the cheek and opercular regions silvery golden. The iris of the eyes is also golden. The fin membranes are hyaline distally and brilliant red over the basal portions, especially in ripe breeding males. The fin rays are brown with the fork of the branched rays darker brown or black giving a banded effect.

The lateral line runs straight from the head to the base of the caudal fin and is generally complete. The cephalic lateral line is disjunct at the dorsal or posterior end of the pre-opercular branch. The mandibular canal is completely absent.

As with other *Pseudobarbus* species the supraneural bones are vestigial or absent and the anterior epipleurals are reduced and poorly ossified. The neurocranium of this species is relatively narrow and deep and the hyomandibular has short dorso-anterior projections.

Distribution

Pseudobarbus phlegethon is endemic to the Clanwilliam Olifants River system (Fig. 34). Within the system it is confined to clear water tributaries of the valley mainstream with only a single population known from the eastern drainage of the Cedarberg mountains (the Driehoek River). Valley tributaries where the species has been collected include the Ratels, the Oudste, the Thee, the Noordhoeks, the Boontjies and the Jan Diessels.

Notes on biology

Underwater observations on this species in the Noordhoeks River on the 7 January 1981 (Skelton, pers. obs.) indicate that mature males in ripe-running breeding condition are territorial.

Conservation status

The fiery redfin is an endangered species (Skelton, 1987).

Etymology

The name "phlegethon" is taken from the mythical fiery river of the underworld and refers to the heat of the Clanwilliam Olifants River valley during summer (Jubb, 1965).

Pseudobarbus tenuis (Barnard 1938)

Fig. 40.

Synonymy

Barbus anoplus (non Weber): Gilchrist and Thompson 1913, 428 (in part, specimens from the Le Roux River).

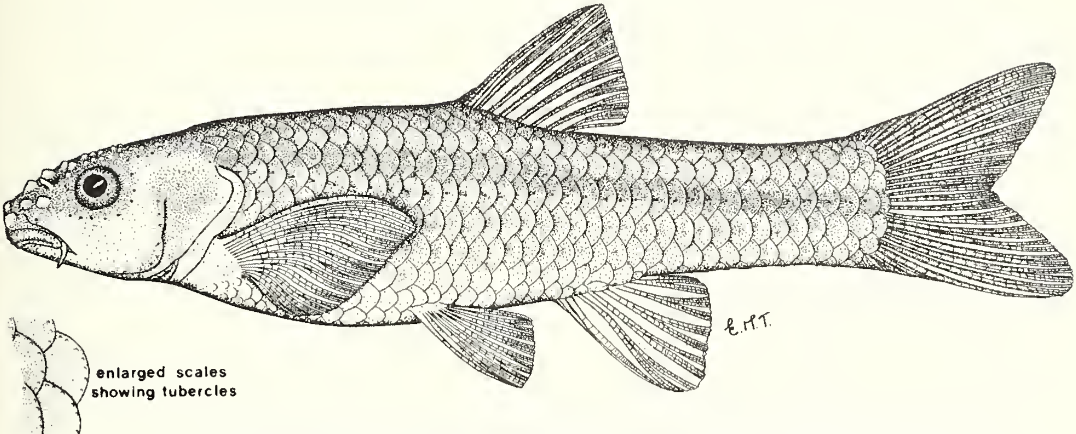

Fig. 40. *Pseudobarbus tenuis* (Barnard 1938), AMG/P 3455, male, 62,5 mm SL. Drawn by E. Tarr.

Barbus tenuis Barnard 1938, 87, type locality "Gouritz River system"; Barnard 1943, 202–204, Fig. 19b; Jubb 1965, 31, Fig. 12; Jubb 1967, 101, Fig. 87; Skelton 1976, Fig. 10b.

Material examined

Lectotype: SAM 18953, female, 74 mm SL, collected by K. H. Barnard, C. W. Thorne and A. C. Harrison from between De Rust and Rust-en-Vrede (probably the Nels River) on the 24 October 1937.

Paralectotypes: SAM 18953, 313 specimens, collected with the lectotype; (SAM 10667, 3 specimens, Le Roux River); SAM 18946, 220 specimens, Seven Weeks Poort, K. H. Barnard, October 1937; SAM 18969, 192 specimens, Grobbelaars River, K. H. Barnard, 24 October 1937;(SAM 18970, Langtouw River, K. H. Barnard, 26 October 1937).

Other material: a—Gourits River system: BMNH 1938.2.28:7–8, tributary of Olifants R, (Gourits system), K. H. Barnard; SAM 19535, Waterval R, Kammanassie, K. H. Barnard, January 1940; SAM 22332, Moeras R; AMG/P 608, Meiringspoort, R. A. Jubb, October 1961; AMG/P 1569, Meiringspoort, C. M. Gaigher, November 1970; AMG/P 1587, Waterkloof R, C. M. Gaigher, May 1971; AMG/P 1935, Wilge R, P. H. Skelton, April 1973; AMG/P 2081, Wilge R, P. H. Skelton, December 1973; AMG/P 2664, Rusoord, P. H. Skelton, January 1975; AMG/P 2666, Waterkloof R, P. H. Skelton, January 1975; AMG/P 2667, Kruis R, P. H. Skelton, January 1975; AMG/P 2945, Meiringspoort, R. A. Jubb, November 1960; AMG/P 2946, Meiringspoort, R. A. Jubb, October 1960; AMG/P 3455, Wilge R, P. H. Skelton, October 1975; AMG/P 4288, Meiringspoort, M. Currey, March 1977; AMG/P 4809 Bo-Buffelskloof, S. Rudd, April 1977; AMG/P 4920, Seven Weeks Poort, R. Boycott, January 1977; AMG/P 6030, Kruis R, S. C. Thorne, August 1978; AMG/P 6031, 6032,6036, 6038, Nels R, S. C. Thorne, August 1978; AMG/P 6060, Groot R, S. C. Thorne, August 1978; AMG/P 6063, 6064,6067, 6071, Meiringspoort, S. C. Thorne, August 1978; AMG/P 6081, 6082, Le Roux R, S. C. Thorne, August 1978; AMG/P 6121, Seven Weeks Poort, S. C. Thorne, August 1978; AMG/P 6161, Jan Muller Bridge, S. C. Thorne, August 1978.

b—Keurbooms River System: AMG/P 2944, Diep R, P. H. Skelton, September 1972; AMG/P 3462, Diep R, P. H. Skelton, October 1975; AMG/P 3822, Bitou R, D. Heard, October

1976; AMG/P 3824, Diep R, D. Heard, October 1976; AMG/P 3825, Voogste R, D. Heard, October 1976.

Notes on the Taxonomy

Jubb (1965) gave the type material of *B. tenuis* as lost. As noted above, the present author considers that the material available to Dr Barnard prior to the publication of the original description represents the type material. Therefore the type material of *P. tenuis* is considered to include the following samples SAM 10667, SAM 18946, SAM 18953, SAM 18969 and SAM 18970. Of these only SAM 18946, SAM 18953 and SAM 18969 have been traced. A lectotype has been selected from SAM 18953 which was collected from between De Rust and Rust-en-vrede (probably the Nels River) on 24 October 1937 by Dr K. H. Barnard, C. W. Thorne and A. C. Harrison.

Diagnosis

A terete redfin minnow with the length of the head greater than the depth of the body. A single pair of relatively short barbels (less than the orbit diameter). The pharyngeal teeth in two rows only 3, 5–5, 3. The intestine short, up to 1,3 times the SL with a single major flexure and slight secondary involutions in large specimens. The pelvic fins have seven rays only. In addition to these characters *P. tenuis* is distinguished from *P. afer* and *P. asper* by the pigment pattern (especially the bold mid-dorsal stripe) and the greater number of striae on the scales.

Description

The morphometric and meristic measurements of *P. tenuis* are given in Table 17. The species is more slender than other redfins and has a terete body shape. The head length is greater than the body depth and the lateral head profile is acutely rounded. The eyes are dorso-lateral in position and are not generally visible from below. The protrusible mouth is sickle-shaped and inferior, with moderately developed lips. There are single short simple barbels at the angles of the mouth. The gill openings are attached at the isthmus.

TABLE 17.

Morphometric and meristic measurements of *P. tenuis* (N=96)

Measurement	*Range*		
	Max.	Min.	$\overline{M}$
Standard length (mm)	80,0	30,0	
Head length (%SL)	30,0	24,6	26,7
Head depth (%HL)	71,2	61,1	65,9
Snout length (%HL)	42,4	30,7	35,0
Orbit diameter (%HL)	30,2	20,6	26,0
Postorbit length (%HL)	54,4	43,7	47,5
Interorbit length (%HL)	35,7	25,3	30,1
Predorsal length (%SL)	54,6	48,3	51,4
Postdorsal length (%SL)	51,7	45,5	48,6
Dorsal fin base (%SL)	14,3	11,0	12,6
Dorsal fin length (%SL)	28,0	19,7	22,8

Measurement	*Range*		
	Max.	Min.	$\overline{M}$
Pectoral fin length (%SL)	24,3	16,7	21,0
Pelvic fin length (%SL)	18,1	10,9	15,8
Anal fin length (%SL)	24,1	16,9	20,1
Anal fin base (%SL)	12,9	8,2	10,4
Body depth (%SL)	26,8	18,8	22,4
Body width (%SL)	20,4	13,3	16,6
Caudal peduncle length (%SL)	29,2	23,1	26,3
Caudal peduncle depth (%SL)	21,1	10,5	12,3
Anterior barbel length (%OD) (N = 8)	27,8	7,7	16,8
Posterior barbel length (%OD)	100,0	20,0	68,1
Pectoral–pelvic length (%SL)	28,5	22,4	25,3
Pelvic–anal length (%SL)	18,2	12,5	14,5
Pharyngeal bones L/W (N = 72)	4,6	3,1	3,8
Length of intestine (%SL) (N = 23)	133,9	77,1	103,3

Meristics	
Dorsal fin rays	iii–iv (iii) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 5–6 (5)
Pectoral fin rays	12–16 (14)
Pelvic fin rays	7–8 (7)
Total Vertebrae	33–38 (36–37)
Precaudal vertebrae	17–19 (18)
Caudal vertebrae	16–19 (18)
Predorsal vertebrae	11–13 (12)
Preanal vertebrae	17–20 (19)
Lateral line scales	32–37 (35–36)
Caudal peduncle scale rows	11–16 (12)
Scale rows lat. line–dorsal	4–6 (5)
Scale rows lat. line–pelvic	3–5 (4)
Scale rows lat. line–anal	3–5 (4)
Predorsal scale rows	14–22 (16)
Primary scale radii ($\overline{M}$ to nearest whole no.)	14
Pharyngeal teeth (mode)	3, 5–5, 3

The body is rounded or slightly depressed in transverse section with the caudal peduncle usually slightly more than twice as long as deep. The scales are cycloid with a mode of 14 primary radial striae from a central focus in all scale fields. The breast scales are reduced and embedded, the scales on the nape are either absent or reduced and crowded, there are no triangular pelvic axillary scales.

In males the paired fins are longer, more rounded and expansive than in the females. The pectorals reach the base of the pelvics and the pelvics reach the anterior base of the anal in males. The posterior edge of the dorsal and anal fins is straight or only slightly convex. The caudal fin is forked with obtusely rounded lobes. The dorsal fin originates behind (posterior to) the origin of the base of the pelvic fins.

The gill rakers are short with 2–3 + 5–8 on the anterior arch. The pharyngeal bones are falcate with a length to width ratio of 3–4,5. There are two rows of pharyngeal teeth, 3, 5–5, 3. The pharyngeal teeth have oblique crowns with single recurved pointed cusps. The intestine is reflexed in a single coil with shallow secondary involutions in larger specimens.

Mature breeding males develop large conical tubercles on the head with a similar pattern to that described in detail for *P. burchelli*. In well developed series there are clusters of up to four or five tubercles on either side of the midline on the snout. Single rows of small tubercles develop over the pectoral branched rays, as well as along the free edge of the body scales.

The colour is basically an olive brown above with lighter underparts with the intensity and particular shade depending on the environment. The pigment pattern of *P. tenuis* is distinctive with a prominent mid-dorsal stripe, which may be interrupted, running from the nape to the dorsal fin and continuing behind the dorsal fin to the base of the caudal. A single mid-lateral band runs on either side from behind the head to the base of the caudal fin. The proximal portion of the fins is scarlet in adult fishes, the fin rays are light brown and the distal membranes hyaline. The iris of the eye is golden and the opercles are metallic silvery-gold.

The lateral line is complete and runs more-or-less straight along mid-body to the end of the caudal peduncle. The cephalic lateral line network lacks a mandibular portion and the preopercular canal is disjunct from the post-ocular commissure.

The neurocranium of this species is relatively broad and shallow and anterior bones are lightly ossified. The hyomandibular is elongated and the supraorbitals are small or vestigial. The supraneurals are vestigial or absent.

Distribution

P. tenuis is found in both the Gourits and the Keurbooms River systems. In the Gourits the species is restricted to tributaries of the Cape Fold Mountains and is not encountered in the lowland mainstreams.

Conservation status

The slender redfin is listed as a rare species in the South African Red Data Book, Fishes (Skelton, 1987).

Etymology

The name *tenuis* refers to the relatively slender profile of the species.

Pseudobarbus afer (Peters 1864)

Fig. 41.

Synonymy

Barbus (Capoeta) afer Peters 1864, 395, Type locality: "Cap der guten Hoffnung"; Günther 1868, 148; non Boulenger 1911, 178, Fig. 156; non Gilchrist and Thompson 1913, 430, Fig. 88; Barnard 1938b, 85; Barnard 1943, 217; Jubb 1965, 29–30, Fig. 11; Jubb 1967, 101, Fig. 88.

Barbus anoplus (non Weber 1894): Boulenger 1911, 177, Fig. 155 (in part, the specimens from the Baakens River, Port Elizabeth); Gilchrist and Thompson 1917, Fig. 87.

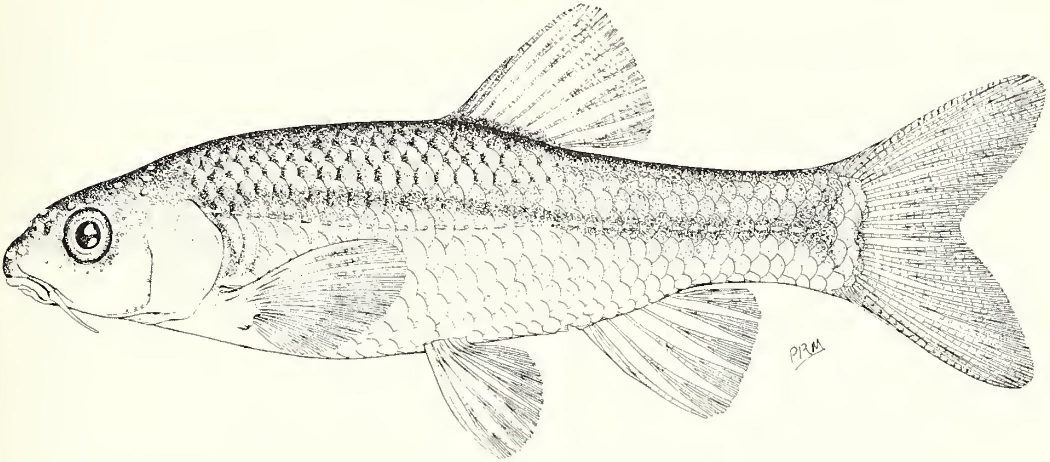

Fig. 41. *Pseudobarbus afer* (Peters 1864), AMG/P 9514, male, 62 mm SL. Drawn by P. Meakin.

Barbus vulneratus (non Castelnau 1861): Gilchrist and Thompson 1913, 415–416 (in part, specimens from the Baakens and Swartkops Rivers).

Barbus senticeps Smith 1936, 266–267, Fig. 3; Smith 1937, 124–125, Fig. 2; Barnard 1938b, 84; Barnard 1943, 200–202.

Barbus asper (non Boulenger 1911): Barnard 1943, 196–200 (in part, specimens listed under (b) and (c) on p.197); Jubb 1965, 28–29, Fig. 10, pl. VIII (in part, specimens from localities other than the Gourits River system and the Groot River, Gamtoos River system); Smith and Smith 1966, 154, Fig. unnumbered.

Material examined

a—Sundays River system, all from the Wit River tributary: AMG/P 455, R. A. Jubb, April 1959; AMG/P 586, R. A. Jubb, 1960; AMG/P 755, R. A. Jubb, April 1959; AMG/P 1188, B. Donnelly, February 1965; AMG/P 3843, P. H. Skelton, December 1976; AMG/P 7465, P. H. Skelton, December 1977.

b—Swartkops River system: SAM 18592, Swartkops R, C. L. Biden, 1935; SAM 19208, Groendal R, C. W. Thorne, October 1938; SAM 19212, Swartkops R; SAM 22330, Swartkops R, Arense; SAM 22334, Swartkops R; AMG/P 675, Elands R, R. A. Jubb, February 1964; AMG/P 2524, Elands R, P. H. Skelton, September 1974; AMG/P 3786, Bulk R, D. Heard, October 1976.

c—Baakens River: SAM 10654, PE Museum, pre-1913; AMG/P 776, D. Bickell, January 1964; AMG/P 1810, P. H. Skelton, November 1972.

d—Maitlands River: AMG/P 5835, A. Bok, January 1978.

e—Gamtoos River system: SAM 19216, Loerie R, C. W. Thorne, October 1938; SAM 19319, Patensie, C. W. Thorne, October 1938; SAM 19496, Baviaanskloof R, K. H. Barnard, April 1939; AMG/P 473, Baviaanskloof R; AMG/P 676, Loerie R, F. L. Farquharson, 1964; AMG/P 712, Moordenaars R, R. A. Jubb, February 1958; AMG/P 1374, 1375, 1376, 1389, 1390, 1413, Couga Dam, F. L. Farquharson, July 1967; AMG/P 1402, 1412, Wit R, F. L. Farquharson, July 1967; AMG/P 1415, 1416, Loerie Dam, F. L. Farquharson, July 1967; AMG/P 1562, 1563, Hankey, C. M. Gaigher, October 1970; AMG/P 1741, Wit R, P. H. Skelton, June 1972; AMG/P 1742, 1803, Bukkraal R, P. H. Skelton, June 1972; AMG/P 1751, Kleinberg R, H. Hofmeyer, November 1964; AMG/P 1921, Wit R, P. H. Skelton, April 1973; AMG/P 2533, Hankey, B. Donnelly, August 1966; AMG/P 3789, Hankey, D. Heard, October 1976; AMG/P 3792, Diepkloof R, D. Heard, October 1976; AMG/P 5841, Wit R, J. Hoffman, March 1977; AMG/P 7465, Wit R.

f—Kabeljous River: SAM 19321, C. W. Thorne, November 1938; AMG/P 3805, Kranzplaas, D. Heard, October 1976; AMG/P 3807, Misgund, D. Heard, October 1976.

g—Seekoei River: SAM 19323, C. W. Thorne, November 1938.

h—Kromme River: SAM 19325, Geelhoutboom R, C. W. Thorne, November 1938; SAM 19326, C. W. Thorne, November 1938; AMG/P 230, Assegaaibos, R. A. Jubb, February 1958; AMG/P 1739, Assegaaibos, P. H. Skelton, June 1972; AMG/P 1801, Assegaaibos, P. H. Skelton, September 1972; AMG/P 2082, Assegaaibos, P. H. Skelton, December 1973; AMG/P 2651, Assegaaibos, P. H. Skelton, January 1975; AMG/P 3103, Assegaaibos, ex aquarium, August 1975; AMG/P 3460, Assegaaibos, P. H. Skelton, October 1975; AMG/P 3810, Assegaaibos, D. Heard, October 1976; AMG/P 3811, Melkhoutkraal, D. Heard, October 1976; AMG/P 3812, Witels R, D. Heard, October 1976; AMG/P 3813, Damsekloof, D. Heard, October 1976; AMG/P 3815, Eerstedrif R, D. Heard, October 1976; RUSI 304, Holotype, *Barbus senticeps*, Assegaaibos, J. L. B. Smith.

i—Tsitsikamma River: AMG/P 3568, Sarnia, P. H. Skelton, October 1975; AMG/P 3816, 3817, Palmiet R, D. Heard, October 1976.

j—Bloukrans River system: AMG/P 1707, 1742, P. H. Skelton, April 1972; AMG/P 2652, P. H. Skelton, January 1975; AMG/P 2654, Vark R, P. H. Skelton, January 1975; RUSI 75–120, J. L. B. Smith, March 1965.

k—Groot River: AMG/P 1706, P. H. Skelton, April 1972; AMG/P 2656, P. H. Skelton, January 1975; AMG/P 3456, P. H. Skelton, October 1975.

l—Keurbooms River system: SAM 19334, Edmonton, C. W. Thorne, November 1938; SAM 19335, Paardekop, C. W. Thorne, November 1938; SAM 19337, C. W. Thorne, November 1938; SAM 22333, no data; AMG/P 1784, Diep R, P. H. Skelton, September 1972; AMG/P 1789, De Vlug, P. H. Skelton, September 1972; AMG/P 3461, Diep R, P. H. Skelton, October 1975; AMG/P 3823, Diep R, D. Heard, October 1976; AMG/P 3826, Boegoeskraal, D. Heard, October 1976.

m—Knysna River system: AMG/P 113, Gouna R, R. A. Jubb; AMG/P 152, R. A. Jubb, February 1958; AMG/P 1790, Grootkop R, P. H. Skelton, September 1972.

n—Goukamma river: SAM 19338, Homtini R, C. W. Thorne, November 1938; AMG/P 100, Homtini R, R. A. Jubb, November 1957; AMG/P 110, Homtini R, R. A. Jubb; AMG/P 584, Homtini R, R. A. Jubb, 1958.

o—Karatara River: SAM 19196, Ruigtevlei, C. W. Thorne, October 1938; SAM 19343, Ruigtevlei, C. W. Thorne, November 1938; AMG/P 1793, P. H. Skelton, October 1972.

p—Klein Brak River: SAM 19345, Haalkraal, C. W. Thorne, November 1938.

Notes on the taxonomy

The identity of *B. afer* remained obscure until Jubb (1965) re-examined the three syntypes of the species from the Berlin Museum. The original locality of the species was given by Peters

(1864) as "Cape of Good Hope". The specimens were collected by Ludwig Krebs during the 1820's when he spent some time in the Port Elizabeth–Uitenhage area (ffolliott and Liversidge, 1971). Dr R. Liversidge discussed the probable original collecting locality with Dr R. A. Jubb (Jubb, pers. comm.) and on the available evidence they concluded that the likely locality was the Swartkops River system (Jubb, 1965).

Diagnosis

A fusiform redfin minnow with a single pair of (usually) long barbels and moderately large scales. The intestine is involuted and extends to 2,3 times the SL in adult specimens. The pigmentation frequently includes a mid-lateral band on the body and a bi-lateral series of predorsal spots. *Pseudobarbus afer* is most similar to *P. asper* from which it differs in having larger scales, a relatively shorter intestine and in details of pigmentation. It is also superficially similar to *P. tenuis* from which it may be distinguished by its deeper body proportions and differences in pigmentation (*P. afer* usually does not have a dark mid-predorsal stripe characteristic of *P. tenuis*). Internally these two species differ in pharyngeal teeth and length of the intestine.

Description

The morphometric and meristic data for *P. afer* are given in Table 18. The species attains 110 mm SL. The length of the head is sub-equal to the depth of the body. The eyes are moderately large and lateral in position. The mouth is sub-terminal, sickle-shaped and protrusible. The lips are moderately fleshy. The barbels attached from behind the rictus of the mouth are usually longer than the orbit diameter in adult specimens. There is, however, considerable interspecific variation between populations in barbel length with longest barbels being recorded from the Tsitsikamma-Knysna area. The body is deepest around the origin of the dorsal and pelvic fins. The caudal peduncle is twice as long as deep. The cycloid scales are radiately striated in all fields from a centralized focus, with a mode of 12 striae. Scales on the chest are reduced and embedded and there are no distinctive triangular pelvic axillary scales.

TABLE 18.

Morphometric and meristic measurements of *P. afer* (N=287)

Measurement	*Range*		$\overline{M}$
	Max.	Min.	
Standard length (mm)	104,0	43,0	
Head length (%SL)	30,4	25,4	27,9
Head depth (%HL)	79,4	62,1	71,5
Snout length (%HL)	41,8	29,7	34,9
Orbit diameter (%HL)	32,9	18,7	26,5
Postorbit length (%HL)	51,2	42,2	45,9
Interorbit length (%HL)	39,2	24,5	29,8
Predorsal length (%SL)	55,7	48,7	52,0
Postdorsal length (%SL)	50,9	44,3	48,0
Dorsal fin base (%SL)	15,8	11,0	13,4

Measurement		*Range*		
		Max.	Min.	$\overline{M}$
Dorsal fin length (%SL)		26,9	17,6	23,4
Pectoral fin length (%SL)		26,1	16,1	18,5
Pelvic fin length (%SL)		20,4	14,2	17,4
Anal fin length (%SL)		23,5	16,6	20,8
Anal fin base (%SL)		12,2	9,0	20,8
Body depth (%SL)		30,6	22,5	26,3
Body width (%SL)		20,5	11,5	17,1
Caudal peduncle length (%SL)		27,6	21,3	24,6
Caudal peduncle depth (%SL)		14,7	10,3	12,4
Anterior barbel length (%OD)				
Posterior barbel length (%OD)		169,6	37,0	94,4
Pectoral–pelvic length (%SL)		28,2	19,5	24,2
Pelvic–anal length (%SL)		18,4	12,4	14,9
Pharyngeal bones L/W	(N = 212)	4,3	2,7	3,5
Length of intestine	(N = 180)	225,0	68,0	146,7

Meristics	
Dorsal fin rays	iii–iv (iv) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 5–6 (5)
Pectoral fin rays	13–17 (15)
Pelvic fin rays	7–9 (8)
Total Vertebrae	35–39 (36–37)
Precaudal vertebrae	17–20 (18–19)
Caudal vertebrae	16–20 (18–19)
Predorsal vertebrae	11–13 (12)
Preanal vertebrae	18–21 (19–20)
Lateral line scales	25–38 (32–37)
Caudal peduncle scale rows	10–18 (16)
Scale rows lat. line–dorsal	4–7 (5–6)
Scale rows lat. line–pelvic	3–6 (4)
Scale rows lat. line–anal	3–5 (4–5)
Predorsal scale rows	13–22 (15–16)
Primary scale radii ($\overline{M}$ to nearest whole no.)	12
Pharyngeal teeth (mode)	2, 3, 5,–5, 3, 2

The paired fins are sexually dimorphic, being longer and more expansive in males in which the pectorals may reach or extend beyond the base of the pelvics and the pelvics reach the base of the anal. The posterior edge of the dorsal and anal fins is straight or mildly convex. The dorsal fin originates just behind the anterior margins of the pelvic fin bases. The caudal is forked with blunt or rounded lobes.

There are 2–3 + 6–8 short blunt gill rakers on the leading edge of the anterior gill arch. The pharyngeal bones are falcate with a length/width ratio of 2,7–4,2. The pharyngeal tooth formula is usually 2, 3, 5–5, 3, 2 but in certain populations (e.g. the Groot River at Natures Valley) 1, 3, 5–5, 3, 1 predominates. The crowns of the pharyngeal teeth are usually closely applied and obliquely truncate through wear to form a scraping type of occluding surface. The intestine is involuted up to 2,3 times the SL.

Adult males develop large conical tubercles on the snout and head dorsum. The tubercles are best developed in larger specimens during early and mid-summer when breeding takes place. The pattern of the tubercles on the head includes clusters of three to four tubercles on the snout, linear series of tubercles above the nares and orbits and scattered tubercles on top of the head. Bands of minute tubercles three to four deep occur on the dorsal side of branched pectoral fin rays. All other fins have single rows of minute tubercles over the rays and a single row of minute conical tubercles develop on the free edge of the scales.

In life the colour of *P. afer* depends on the habitat: specimens from deeply stained clear waters of the Tsitsikamma region are a dark brown or black with lighter underparts; specimens from lighter environments are olive-brown above and silvery or off-white below. The operculum and iris of the eye are metallic gold with an infusion of red. The fins are hyaline with bright red proximal halves and brown fin-rays. Pigmentation is variable but there is usually a thin unbroken lateral stripe from behind the head to the base of the caudal fin, as well as a bi-lateral series of small spots in the predorsal region or, less frequently, a single mid-predorsal stripe. These markings manifest themselves more clearly in preserved specimens.

The lateral line runs more-or-less straight along mid-body and is either complete or nearly complete. Of the cephalic lateral line system there is no mandibular canal (vestigial segments have been observed in a few individuals) and the preopercular canal is disjunct from the post-ocular commissure.

Distribution

Pseudobarbus afer has been reported from coastal rivers east of the Gourits River system to the Sundays River system which enters Algoa Bay east of Port Elizabeth (Fig. 37A). Along the Outeniqua–Tsitsikamma coastal plain the species is known from only the deeply entrenched river systems of Tertiary origin. A single relict population only is found in the Sundays River system.

Conservation status

P. afer was included in the South African Red Data Book, Fishes as a rare species by Skelton (1977). The taxonomic adjustment of this species by the present study has greatly increased the geographic range of the species. Although many populations have been eliminated and the species is severely depleted in places, overall it is considered safe and is not included in the revised South African Red Data Book, Fishes (Skelton, 1987). Strict conservation of all populations of the species is necessary.

Etymology

The species name *afer* refers to its presence in "Africa."

Pseudobarbus asper (Boulenger 1911).

Fig. 42.

Synonymy

Barbus burchelli (*non* Smith 1841): Weber 1897, 153 (in part, specimens from the Buffels River, Laingsburg and the Kammanassie River).

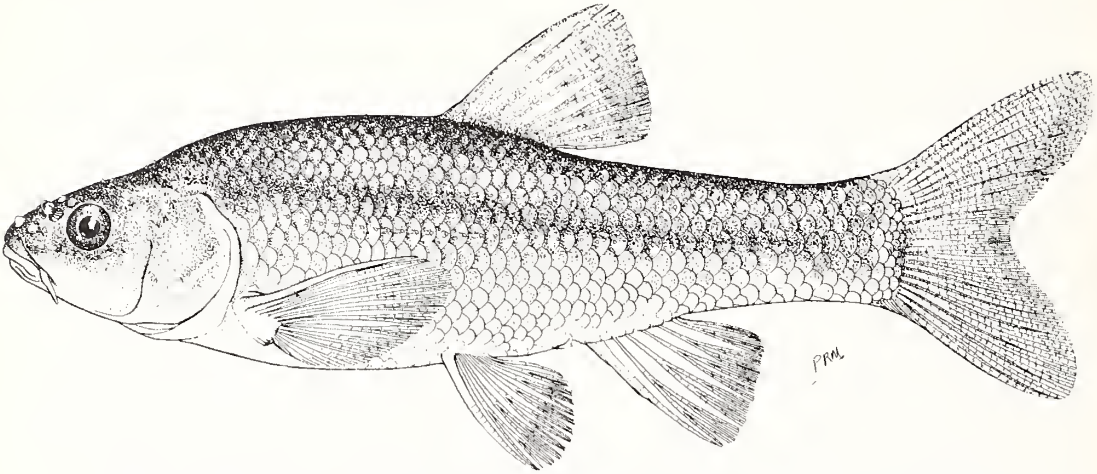

Fig. 42. *Pseudobarbus asper* (Boulenger 1911), AMG/P 9932, male, 63 mm SL, Drawn by P. Meakin.

Barbus asper Boulenger 1911, 176–177, Fig. 154. Type locality: "Cape Colony. Groote R., Sleytlerville. Le Roux R., Ondtsloon." (Sleytlerville = Steytlerville; Ondtsloon = Oudtshoorn). Gilchrist and Thompson 1913, 427–579, Fig. 86; Barnard 1938b, 84; Barnard 1943, 196–200, Fig. 19a (in part, the specimens from locality (a) p. 197, except those from Haalkraal); Jubb 1965, 28–29 (in part, only specimens from the Gourits River system and the Groot River of the Gamtoos River system); Jubb 1967, 99 (in part, only specimens from the Gourits River system and the Groot River of the Gamtoos River system).

Material examined

Holotype: BMNH 1909.12.8.10, male, 73 mm SL, donated by the SAM, collected from Steytlerville on the Groot River, Gamtoos River system.

Paratypes: BMNH 1909.12.8.6–9 , female, 96 mm SL, male 67 mm SL, juvenile 34 mm SL, donated by SAM, collected from the Le Roux River near Oudtshoorn, Gourits River system; SAM 10644, 1 specimen in extremely poor condition, not measured, collected from the Le Roux River near Oudtshoorn, Gourits River system (this specimen is labelled as a "co-type" but is not mentioned by Boulenger 1911 in the original description).

Other material: a—Groot River, Gamtoos River system : SAM 19205, Fullarton, C. W. Thorne, October 1938; SAM 19206, Steytlerville, C. W. Thorne, October 1938; AMG/P 1744, P. H. Skelton, June 1972; AMG/P 1745, Steytlerville, P. H. Skelton, June 1972; AMG/P 3060, Sandfort West, P. H. Skelton, July 1975; AMG/P 3064, Groot River Poort, P. H. Skelton, July 1975; AMG/P 3065, Bucklands, Groot R, P. H. Skelton, July 1975; AMG/P 3066, Weymouth, P. H. Skelton, July 1975; AMG/P 3456, Wit R, 1st drift, P. H. Skelton, October 1975; AMG/P 3458, Wit R, Armansvriend, P. H. Skelton, October 1975.

b—Gourits River system : SAM 10664, Le Roux R; SAM 10673, Grobbelaars R; SAM 14284, Leeus R, S. H. Haughton, 1916; SAM 18945, Grobbelaars R, K. H. Barnard, October 1937; SAM 18957, Langtouw R, K. H. Barnard, October 1937; SAM 18959, Zanddrift, K. H.

Barnard, October 1937; SAM 18952, Meiringspoort, K. H. Barnard, October 1937; SAM 18962, Buffels R, K. H. Barnard, October 1937; SAM 18965, Touws R, K. H. Barnard, October 1937; SAM 18941, Buffels R, K. H. Barnard, October 1937; SAM 19497, Doorn R, K. H. Barnard, April 1939; SAM 18990, Weiders R, K. H. Barnard, February 1938; SAM 18991, Valsch R, K. H. Barnard, February 1938; SAM 18949, Gamka Poort, K. H. Barnard, October 1937; SAM 18956, Moeras R, K. H. Barnard, October 1937; AMG/P 42, Meiringspoort, R. A. Jubb, November 1960; AMG/P 376, Meiringspoort, R. A. Jubb, October 1960; AMG/P 607, Meiringspoort, R. A. Jubb, October 1961; AMG/P 1695 and 1696, Jan Muller Bridge, Touws R, P. H. Skelton, April 1972; AMG/P 1699, VanWyksdorp, P. H. Skelton, April 1972; AMG/P 1703, Gamka R, P. H. Skelton, April 1972; AMG/P 1786, 1787 and 1788, Meiringspoort, P. H. Skelton, September 1972; AMG/P 1943, 1945, Meiringspoort, P. H. Skelton, April 1973; AMG/P 1956, Olifants R, R. E. Stobbs, September 1972; AMG/P 2661, Diep R, P. H. Skelton, January 1975; AMG/P 2663, Rusoord, P. H. Skelton, January 1975; AMG/P 2668, Kruis R, P. H. Skelton, January 1975; AMG/P 4279, Jan Muller Bridge, Touws R, M. Currey, March 1977; AMG/P 4281, VanWyksdorp, M. Currey, March 1977; AMG/P 4289, Meiringspoort, M. Currey, March 1977; AMG/P 6561, Kammanassie R, S. C. Thorne, August 1978; AMG/P 6033, Nels R, S. C. Thorne, August 1978; AMG/P 6045, 6052, Olifants R, S. C. Thorne, August 1978; AMG/P 6055, De Rust, S. C. Thorne, August 1978; AMG/P 6058, 6059, Groot R, S. C. Thorne, August 1978; AMG/P 6062, 6065, 6066, 6068, 6070, 6072, Meiringspoort, S. C. Thorne, August 1978; AMG/P 6078, Kammanassie R, S. C. Thorne, August 1978; AMG/P 6085, Grobbelaars R, S. C. Thorne, August 1978; AMG/P 6099, Olifants R, S. C. Thorne, August 1978; AMG/P 6103, Gourits R, S. C. Thorne, August 1978; AMG/P 6107, 6112, Groot R, S. C. Thorne, August 1978; AMG/P 6115, Touws R, S. C. Thorne, August 1978; AMG/P 6118, Groot R, S. C. Thorne, August 1978; AMG/P 6123, Gamka R, S. C. Thorne, August 1978; AMG/P 6128, Brak R, S. C. Thorne, August 1978; AMG/P 6131, 6133, Jan Muller Bridge, Touws R, S. C. Thorne, August 1978; AMG/P 6136, Weiders R, S. C. Thorne, August 1978; AMG/P 6561, Kammanassie R, S. C. Thorne, August 1978; RUSI 75–139, Kammanassie R.

Diagnosis

A relatively deep-bodied fusiform redfin minnow with a single pair of barbels and small scales (35–45 in the lateral line series). The pharyngeal teeth are obliquely worn and the intestine is relatively long and involuted up to 3,8 times the SL. The pigmentation is distinct with fine melanophores within the scale centres giving a "speckled hen" effect. The small scales and deep body, pharyngeal teeth and longer intestine separate this species from *P. tenuis* with which it is found in the Gourits River system. The small scales, pigmentation and longer intestine distinguishes this species from *P. afer* in the Gamtoos River system.

Description

Morphometric and meristic measurement data for *P. asper* are given in Table 19. The head is subequal to the body depth and the lateral head profile is rounded. The eyes are lateral in position. The mouth is sub-terminal and sickle-shaped with thin to moderately thick lips. The single, simple barbels from the corners of the mouth are shorter than the orbit diameter in adults. The gill openings are broadly attached to the isthmus.

The body is oval in cross-section and the caudal peduncle slightly more than twice as long as deep. The scales are cycloid and radiately striated with a mode of 11 radii in all fields from a central focus. Breast and ventral scales between the pectoral and pelvic fins are reduced in size

TABLE 19.

Morphometric and meristic measurements of *P. asper* (N = 110)

Measurement		*Range*		
		Max.	Min.	$\overline{M}$
Standard length (mm)		80,0	43,0	58,9
Head length (%SL)		28,2	24,7	26,5
Head depth (%HL)		76,4	66,8	71,7
Snout length (%HL)		38,0	31,1	33,9
Orbit diameter (%HL)		28,7	22,0	26,0
Postorbit length (%HL)		52,1	37,8	47,0
Interorbit length (%HL)		35,2	25,5	31,2
Predorsal length (%SL)		54,6	47,8	51,0
Postdorsal length (%SL)		52,2	45,5	49,0
Dorsal fin base (%SL)		15,7	11,3	13,2
Dorsal fin length (%SL)		27,9	18,9	23,0
Pectoral fin length (%SL)		26,1	17,0	21,1
Pelvic fin length (%SL)		21,8	12,6	16,6
Anal fin length (%SL)		24,3	16,8	20,2
Anal fin base (%SL)		13,3	8,5	10,2
Body depth (%SL)		29,5	21,5	26,4
Body width (%SL)		20,0	10,9	16,7
Caudal peduncle length (%SL)		29,6	21,5	25,3
Caudal peduncle depth (%SL)		13,2	9,6	11,6
Anterior barbel length (%OD)		—	—	—
Posterior barbel length (%OD)		116,3	46,0	70,7
Pectoral–pelvic length (%SL)		29,8	21,1	25,1
Pelvic–anal length (%SL)		17,6	11,8	14,6
Pharyngeal bones L/W	(N = 74)	4,0	2,8	3,3
Length of intestine (%SL)	(N = 81)	381,6	124,2	240,0

Meristics	
Dorsal fin rays	iii–iv (iv) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 5–6 (5)
Pectoral fin rays	14–17 (15–16)
Pelvic fin rays	7–9 (8)
Total Vertebrae	35–38 (36)
Precaudal vertebrae	17–20 (19)
Caudal vertebrae	16–19 (17–18)
Predorsal vertebrae	11–13 (12)
Preanal vertebrae	18–21 (19–20)
Lateral line scales	35–45 (37–40)
Caudal peduncle scale rows	16–22 (18–20)
Scale rows lat. line–dorsal	6–9 (7–8)
Scale rows lat. line–pelvic	5–8 (6)

Meristics	
Scale rows lat. line–anal	5–8 (6)
Predorsal scale rows	18–26 (21–22)
Primary scale radii ($\overline{M}$ to nearest whole no.)	11
Pharyngeal teeth (mode)	2, 3, 5–5, 3, 2

and deeply embedded. The nape scales are reduced and crowded. There are no trianguloid or elongated pelvic axillary scales.

In adults the paired fins are sexually dimorphic with males having longer more expansive fins than the females. The pectorals reach the base of the pelvic fins in adult males. The fins of the Gamtoos River specimens are relatively longer than those of specimens from the Gourits system. The pelvics are sub-rectangular reaching the anterior base of the anal fin in adult males. The posterior edge of the dorsal and anal fins is straight or slightly convex. The anterior origin of the dorsal fin is placed behind the origin of the pelvic fins. The caudal fin is forked with narrowly rounded lobes.

There are 2–4 + 7–10 short, stubby gill rakers on the leading arch. The pharyngeal bones are falcate with a length/width ratio of 2,8–4. The pharyngeal teeth are in three rows with a formula of 2, 3, 5–5, 3, 2. The crowns of the pharyngeal teeth are closely applied and obliquely truncated to form an effective scraping type of occlusal surface. The intestine is long and involuted in a series of coils. The peritoneum is black.

Breeding males develop large conical tubercles on the head dorsum and on the snout. The pattern, size and number of these tubercles is similar to *P. afer*. In addition bands of fine tubercles up to three or four deep develop over the branched pectoral fin rays, with single rows of minute tubercles on the rays of other fins and a single row along the posterior free edge of the scales. Large mature and ripe females may develop a few small tubercles on the head dorsum.

The general colour of *P. asper* depends on the habitat but is usually light brownish above with silvery flanks and whitish underparts. There is an uneven dark lateral band from behind the head to the base of the caudal fin. Fine melanophores in the scale centres give an overall "speckled hen" appearance. The opercula are metallic golden and the iris of the eyes silvery-golden. The proximal half of the fins becomes bright scarlet in adults especially in mature and ripe males. Distal fin membranes are hyaline and the rays are a light brown.

The lateral line is generally incomplete and runs more-or-less straight along the mid-body. The cephalic lateral line lacks a mandibular canal and the pre-opercular canal is disjunct from the post-ocular commissure. As with other *Pseudobarbus* species the supraneural bones are vestigial or absent and the anterior epineurals are poorly ossified and reduced.

Distribution

P. asper occurs in the Groot River of the Gamtoos River system as well as in the larger tributaries and mainstream of the Gourits River system (Figs. 35 and 37A). It is often found in standing water bodies and has been collected in large numbers in certain localities.

Conservation status

P. asper was considered a rare species by Skelton (1977). In a recent reassessment of this status the species is now regarded as "safe" and is not included in the revised version of the

South African Red Data Book, Fishes (Skelton, 1987). The reason for this change is that distribution surveys of the Gourits and Gamtoos River systems by the CDNEC show the species to be widespread and relatively common throughout its range. It can survive harsh conditions in temporary pools and does well in impounded waters (Gaigher *et al.*, 1980).

Etymology

The name *asper* refers to the rough tubercles on the head of males.

Pseudobarbus quathlambae (Barnard 1938)

Fig. 43.

Synonymy

Labeo quathlambae Barnard 1938a, 525–528, Fig. p. 52, type locality: "Upper Umkomazana River, at an altitude of about 5300 ft. Himeville"; Jubb 1966a, 161–162; Jubb 1966b, 78–80; Jubb 1967, 115, Fig. 117 a, b.

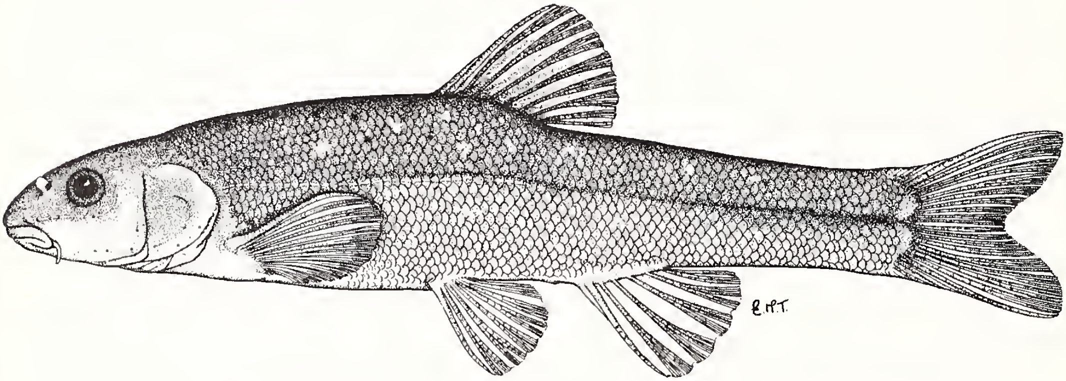

Fig. 43. *Pseudobarbus quathlambae* (Barnard 1938), AMG/P 3473, male, 95 mm SL. Drawn by E. Tarr.

Oreodaimon quathlambae, Greenwood and Jubb 1967, 17–37, 17 figures; Jubb 1971, 4–7; Pike and Tedder 1973, 9–15; Skelton 1974 a, 215–222; Skelton 1976, 407–408, Fig 10a; Rondorf 1976, 150–151; Gephard 1978, 105–111.

Material examined

Lectotype: SAM 19018, female, 80 mm SL, Upper Umkomazana River near Himeville, Natal, R. S. P. Vaughan, 1937.

Paralectotypes: SAM 19018, 14 specimens 28–71 mm SL, collected from the Upper Umkomazana River near Himeville, Natal, by A. M. Copland, August 1937; NMP 1416, 33 specimens 30–37.8 mm SL, collected with the other paralectotypes.

Other material: all Orange River system in Lesotho: AMG/P 1540 and 3477, Tsoelikana R, A. Tedder, November 1970; AMG/P 1877, 3476, 3478, Tsoelikana R, A. Tedder, April 1972;

AMG/P 1823, 1824, Tsoelikana R, P. H. Skelton, January 1973; AMG/P 3473, Tsoelikana R, P. H. Skelton, October 1975; AMG/P 3474, Tsoelikana River, D. Rondorf, Nov 1974; AMG/P 3475, Tsoelikana R, D. Rondorf, January 1975; AMG/P 3479, Moremoholo R, D. Rondorf, July 1975; AMG/P 3480, Senqu R, D. Rondorf, August 1975; RUSI 25491, Jordane R, tributary of the Senqunyane R, K. J. Meyer, 27 October 1985.

Notes on the taxonomy

Barnard (1938a) described this species from 58 specimens of which the author has been able to locate the above 48 in the SAM and NMP collections. As clearly stated by the then editor of the Annals of the Natal Museum, Mr R. J. P. Vaughan collected the first specimen, which is the largest in the type series. This specimen was designated the lectotype by Greenwood and Jubb (1967). Barnard (1938a) stated that a second specimen was obtained from the same locality as the lectotype but this specimen cannot be differentiated from other paralectotypes because its dimensions were not specified in the original description.

In regard to the type locality, Crass (1977 and 1985) believes that the original specimens may have come from Lesotho and not the Umkomazana River. Crass's argument is based on the fact that the species is now known from Lesotho and has not been found since in the Umkomazana River. Furthermore the Sani Pass (Umkomazana River valley) was an important trade route to Natal from Lesotho. Against this argument is the published information by Barnard (1938a) supported by the editor and then Director of the Natal Museum, Dr R. F. Lawrence, that the specimens came from the Upper Umkomazana River near Himeville. In addition there is a letter written by Mr R. S. P. Vaughan to Dr R. A. Jubb in 1966 (RUSI files) in which he states explicitly: "I remember the occasion when I went to the Umkomazana River with J. McVey Brown and Hardingham (both of whom have since died). Copland had nothing to do with catching these minnows. He either took or sent the specimens to P. M. Burg." The author therefore believes that the evidence supports the Umkomazana River as the type locality, and that subsequently the species has been extirpated from that locality. A description of the type locality is given by Greenwood and Jubb (1967) and Jubb (1971).

Diagnosis

This is an unmistakeable species with extremely small scales, a single pair of short barbels, pharyngeal teeth in two rows only and the intestine is relatively short, subequal to the SL. *Pseudobarbus quathlambae* is most similar to *P. tenuis* but cannot be confused with this latter species on account of the large difference in scale size between them.

Description

The morphometric and meristic data are given in Table 20. The species attains 130 mm SL and has a terete body with the length of the head greater than the body depth. The head profile is bluntly rounded or ellipsoid and the mouth is sub-terminal in position. The mouth is sickle-shaped and protrusible and the lips are moderately fleshy and well developed. A single short (less than the orbit diameter) simple barbel occurs on either side at the corner or angle of the mouth. The gill openings are broadly attached to the isthmus.

In cross section the body is oval with the caudal peduncle more than twice as long as deep. The tiny scales are radiately striated with a central focus. The ventral scales from the isthmus to the pelvic fins (breast and belly) are reduced and embedded giving a naked appearance to the

Table 20.

Morphometric and meristic measurements of *P. quathlambae* (N=32)

Measurement	*Range*		
	Max.	Min.	$\overline{M}$
Standard length (mm)	102,0	46,0	
Head length (%SL)	27,1	22,7	24,8
Head depth (%HL)	69,4	59,9	64,3
Snout length (%HL)	39,3	33,3	36,8
Orbit diameter (%HL)	27,9	19,4	23,6
Postorbit length (%HL)	57,8	46,4	49,7
Interorbit length (%HL)	30,2	24,4	27,4
Predorsal length (%SL)	55,0	47,4	50,8
Postdorsal length (%SL)	52,6	45,0	49,3
Dorsal fin base (%SL)	13,5	10,5	11,9
Dorsal fin length (%SL)	22,0	17,7	19,8
Pectoral fin length (%SL)	21,7	15,5	18,8
Pelvic fin length (%SL)	16,7	12,8	15,1
Anal fin length (%SL)	20,0	15,1	17,5
Anal fin base (%SL)	12,1	8,9	10,2
Body depth (%SL)	25,5	20,0	22,0
Body width (%SL)	16,7	11,9	14,7
Caudal peduncle length (%SL)	28,2	22,8	25,3
Caudal peduncle depth (%SL)	12,1	9,9	11,0
Anterior barbel length (%OD)	—	—	—
Posterior barbel length (%OD)	80,7	34,2	56,3
Pectoral–pelvic length (%SL)	27,7	23,0	25,5
Pelvic–anal length (%SL)	17,5	12,7	14,9
Pharyngeal bones L/W (N = 28)	4,3	2,7	3,2
Length of intestine (%SL) (N = 20)	114,3	77,4	96,2

Meristics	
Dorsal fin rays	iii + 6–8 (7)
Anal fin rays	iii + 5–6 (5)
Pectoral fin rays	15–17 (16)
Pelvic fin rays	7–9 (8)
Total vertebrae	38–40 (39)
Precaudal vertebrae	19–22 (20–21)
Caudal vertebrae	17–20 (18–19)
Predorsal vertebrae	13–15 (14)
Preanal vertebrae	20–22 (21)
Lateral line scales	60–72 (65–67)
Caudal peduncle scale rows	30–38 (32–36)
Scale rows lat. line–dorsal	10–14 (11–12)
Scale rows lat. line–pelvic	8–12 (10–11)

Meristics	
Scale rows lat. line–anal	9–11 (9–10)
Predorsal scale rows	28–40 (34–36)
Primary scale radii ($\overline{M}$ to nearest whole no.)	10
Pharyngeal teeth (mode)	3, 4–4, 3

region. The nape scales are also reduced and there are no elongated or trianguloid pelvic axillary scales. The scales adjacent to the dorsal and anal fin bases are reduced and embedded.

The paired fins of mature males are longer and more rounded than those of the females. In both sexes the pectoral fins do not reach the bases of the pelvic fins and the pelvics do not reach the base of the anal fin. All fins have rounded convex edges and the caudal fin is shallow forked with rounded lobes. The dorsal fin originates behind the anterior base of the pelvic fins.

There are 1–2 + 5–7 short blunt gill rakers on the outer leading edge of the anterior arch. The pharyngeal bones are falcate with a length to width ratio of 2,8–4,3. The pharyngeal teeth are in two rows 3, 4–4, 3. The pharyngeal teeth are semi-cylindrical with deflexed crowns with off-centre recurved conical tips. The intestine is short (sub-equal to the SL) and has a single "S"-flexure.

Sexually mature and ripe adults of both sexes develop small conical tubercles over the dorsal and dorso-lateral parts of the head. There are bands of minute compressed conical tubercles up to six rows across over the branched pectoral fin rays. Single tubercle rows occur over the rays of other fins. There are usually only one or two small conical tubercles on each scale.

Colour depends on the habitat and the physiological state of the individual. Adults vary from a light olive-brown to deep bluish black above and whitish-cream below. The iris is light golden and the operculum metallic gold. Fins are hyaline with light grey or brown rays and the basal membranes and adjacent body regions are bright red. There is usually a dark mid-lateral band from behind the head to the base of the caudal fin. A bi-lateral predorsal series of dark spots or vermiculations form prominent markings on live and preserved specimens from certain populations (see Gephard, 1978).

The lateral line is complete and runs straight mid-laterally along the body. There is no mandibular canal and the pre-opercular canal is reduced anteriorly and disjunct from the post-ocular commissure.

Supraneural bones are vestigial or absent. Anterior epineurals are not ossified and the bones of the anterior portion of the neurocranium are membranous and weakly ossified. Supraorbitals are vestigial and there are usually only four infraorbital bones on either side including the lachrymal.

Distribution

Since its discovery in 1938 the species has not been collected in the type locality (the Umkomazana River) and it is presumed to be extinct there. Populations have been discovered in five tributaries of the Orange or Senqu River in Lesotho (Fig. 37b).

Conservation status

P. quathlambae is an endangered species (Skelton, 1977 and 1987). It is believed to have been eliminated from the type locality in Natal. In Lesotho the few known populations are limited to relatively short stretches of small streams. In general, stream habitats in the Maluti and Drakensberg Mountains are deteriorating through siltation from overgrazing and poor agricultural practices. Increased environmental pressures on these habitats may result from large-scale development projects such as the Lesotho Highlands Water Scheme.

Etymology

The name *quathlambae* is derived from an indigenous African name for the Drakensberg mountains and means "a barrier of spears".

Barbus Cuvier and Cloquet 1816

Type species: *Cyprinus barbus* Linnaeus 1758, by tautonymy.

The genus *Barbus* is generally accepted to be an unnatural and extremely large assemblage of cyprinid species. As many as 292 African species alone were listed by Leveque and Daget (1984). Therefore no attempt is made here to provide a comprehensive definition for this genus (see Howes (1987) for further comments on this problem). Instead certain group characteristics of the two serrated-rayed redfin species and other southern African *Barbus* species are provided for comparison with the genus *Pseudobarbus*.

Some characteristic features of African *Barbus* species are: generally fusiform and slightly compressed bodies; head naked with mouth protrusible and either supra-terminal, terminal or sub-terminal in position; usually one or two pairs of simple barbels but these are absent in some species; lips variable in development frequently showing large intraspecific variation; scales cover entire body , mostly moderate or large in size, cycloid with radiating , convergent or parallel striae in all scale fields; dorsal fin with the last unbranched ray either simple segmented and flexible , simple bony and spinous or bony spinous (with segmented flexible tip) and serrated; anal fin with ii–iv simple and five (occasionally six or seven) branched rays; intestine short with a simple flexure (approximately equal in length to the SL) or moderately elongated and involuted (up to four or five times the SL); pharyngeal bones falcate with three rows of teeth, usually in the formula 2, 3, 5–5, 3, 2; pharyngeal teeth most often hooked or spoon-shaped but also molariform in certain larger species (e.g. Banister 1973).

Characteristic but not necessarily diagnostic features of the two known serrated-rayed redfin species are: anal fin with six or seven branched rays; dorsal fin with last unbranched ray bony and serrated with flexible tip, or segmented and flexible with vestigial serrations; mouth terminal with two pairs of long barbels; pharyngeal bones falcate with hooked or pointed teeth and in three rows with the formula 2, 3, 4 or 5–5 or 4, 3, 2; intestine short (about equal to the SL) in a single flexure; ripe adults of both sexes with scattered minute erupted tubercles (pimples) on the snout and head dorsum, the scales and, in single rows over rays of all fins; cephalic lateral line system with complete preopercular-mandibular canal that is linked to the post-ocular commissure by means of a canal through the antero-dorsal corner of the opercles. Adult fish have bright red patches on the proximal half of fins and adjacent body area. Gill-rakers short, six to nine on the lower limb (ceratobranchial) of the leading gill arch. Total vertebrae 36–39; from five to nine well developed supraneural bones present; frontals overlapping lamellae of supraethmoid; intercalars disc-like and well developed; exoccipitals without posterior flange; supraorbitals slender not in recess in frontals; lachrymal with pointed or angulate dorsal edge; premaxillae slender; urohyal slender with truncate posterior edge. Paired fins not markedly dimorphic. Intramuscular bones well developed from behind the head.

Barbus calidus Barnard 1938.

Fig. 44.

Synonymy

Barbus serra (*non* Peters 1864): Gilchrist and Thompson 1913, 404 (in part—the 2 smaller Leipoldt specimens).

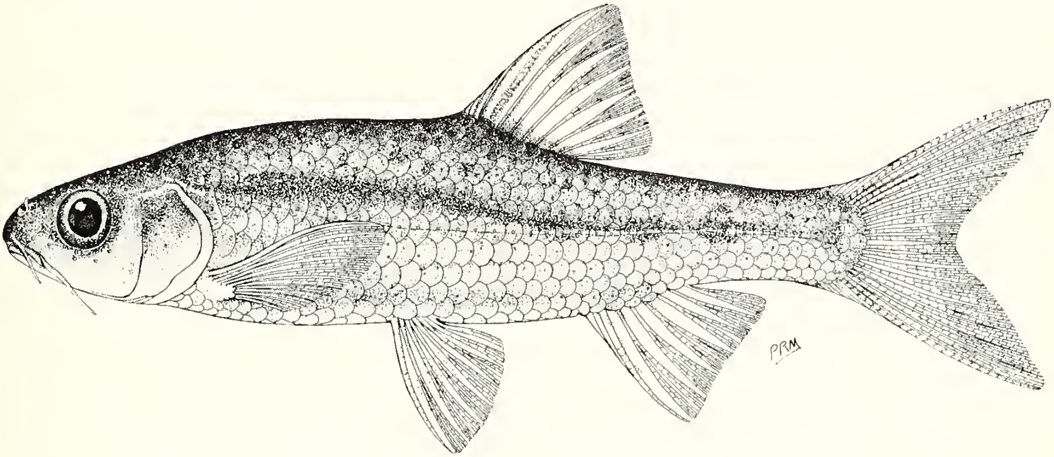

Fig. 44. *Barbus calidus* Barnard 1938, AMG/P 8216, male, 65 mm SL. Drawn by P. Meakin.

Barbus calidus Barnard 1938b, 86. Type locality: "Olifants River system, Clanwilliam, Cape"; Barnard 1943, 176–179, Fig. 15 a–c; Jubb 1965, 25, Fig. 7; Jubb 1967, 95, Fig. 80.

Material examined

Lectotype (new designation): SAM 18605, male, 71 mm SL. Collected by K. H. Barnard and C. W. Thorne, 1936, from the Jan Diessels River, Olifants River system, western Cape Province.

Paralectotypes: SAM 18605, 67, 2–74,6 mm SL, collected with the lectotype; SAM 18606, Tra-Tra River, K. H. Barnard, 1936 (SAM 18605 and SAM 18606 are combined together in one container and the source of individual specimens cannot be determined); SAM 18756, Olifants River, K. H. Barnard, 11 April 1937; the remaining samples of possible paralectotypes have not been seen or traced and are presumed lost—SAM 22499, Boontjies River, K. H. Barnard, November 1936; SAM 215/216, Olifants River, C. L. Leipoldt, 30 November 1897; SAM 2012–2015, Olifants River, Clanwilliam, R. M. Lightfoot.

Other material (all Olifants River system): SAM 19002, Olifants R, K. H. Barnard, 16–18 April 1938; SAM 22478, K. H. Barnard, April 1949; AMG/P 728, Thee R, K. van Rensburg, February 1964; AMG/P 885, K. van Rensburg, 1965; AMG/P 1371, Rondegat R, F. L. Farquharson, April 1967; AMG/P 1393, Keerom, K. van Rensburg, January 1964; AMG/P

1581, Tra-Tra R, R. Louw, November 1968; AMG/P 1644, Noordhoeks R, F. L. Farquharson, April 1967; AMG/P 1797, Rondegat R, P. H. Skelton, September 1972; AMG/P 1818, Thee R, D. Heard, September 1972; AMG/P 1844, Tra-Tra R, P. H. Skelton, January 1973; AMG/P 1850, Jan Diessels R, P. H. Skelton, January 1973; AMG/P 1855, Matjies R, P. H. Skelton, January 1973; AMG/P 1857, Breekkrans R, P. H. Skelton, January 1973; AMG/P 1862, Noordhoeks R, P. H. Skelton, February 1973; AMG/P 1869, Thee R, P. H. Skelton, February 1973; AMG/P 1871, Ratels R, P. H. Skelton, February 1973; AMG/P 1883, Rondegat R, D. Heard, November 1972; AMG/P 2050, Matjies R, P. H. Skelton, October 1973; AMG/P 2051, Noordhoeks R, P. H. Skelton, October 1973; AMG/P 2052, Tra-Tra R, P. H. Skelton, October 1973.

Notes on the taxonomy

Barnard (1938b) did not specifically mention the material he used to describe this species. The lectotype and paralectotypes are taken from all the samples available to Barnard prior to the publication in which it was described. All this material was mentioned in Barnard (1943) but certain samples have not been traced (SAM 215/216/2912/2913/2914/2915 and SAM 22499).

Diagnosis

This is the only redfin minnow with a stout serrated unbranched ray in the dorsal fin and usually six branched rays in the anal fin. The posterior position of the dorsal fin, slender caudal peduncle, terminal mouth with two pairs of barbels, and large eye also distinguish it from other redfin species. It is closest to *B. erubescens* from which it differs in the form of the dorsal fin unbranched ray, the number of anal fin branched rays, the number of predorsal vertebrae, the number and shape of the pharyngeal teeth, and in colour and pigmentation. The number of anal fin branched rays also serves to separate the species from juveniles of the larger *Barbus* species in the Olifants River system (*B. capensis* and *B. serra*).

Description

Morphometric and meristic data are given in Table 21. *B. calidus* is a fusiform minnow species which attains at least 82 mm SL. The length of the head is greater than the body depth. The relatively large mouth is terminal and U-shaped, the lips are thin. There are two pairs of well-developed simple barbels that in adults are equal or greater than the orbit diameter. The relatively large eyes are lateral in position. The branchiostegal membrane is narrowly attached to the isthmus.

The body is completely covered with radiately striated cycloid scales. The radii extend from an anteriorly placed focus in all the scale fields. Chest scales are slightly reduced in size but are distinct and not embedded. A small triangular pelvic axillary scale is present.

The dorsal fin originates behind the pelvic origin and has a straight posterior margin. The last (fourth) unbranched ray is bony and serrated along the posterior edge. The anal fin has three unbranched and six branched rays and the posterior margin is straight. The caudal fin is forked with slender lobes. The pectoral fins are sub-falcate and slender nearly reaching the anterior base of the pelvics. The pelvics are well-developed and triangular in shape. There is no marked sexual dimorphism in the paired fins.

TABLE 21.

Morphometric and meristic measurements of *B. calidus* (N=280)

Measurement	*Range*		$\overline{M}$
	Max.	Min.	
Standard length (mm)	82,0	22,1	51,5
Head length (%SL)	30,0	24,6	27,5
Head depth (%HL)	76,7	60,9	68,2
Snout length (%HL)	40,0	28,1	34,4
Orbit diameter (%HL)	36,4	25,0	29,1
Postorbit length (%HL)	53,3	38,2	43,6
Interorbit length (%HL)	41,7	28,6	34,1
Predorsal length (%SL)	57,5	50,0	54,3
Postdorsal length (%SL)	50,0	42,6	45,7
Dorsal fin base (%SL)	17,0	12,1	13,8
Dorsal fin length (%SL)	26,0	18,4	22,2
Pectoral fin length (%SL)	23,4	18,6	21,2
Pelvic fin length (%SL)	20,2	16,0	18,2
Anal fin length (%SL)	23,3	17,8	19,6
Anal fin base (%SL)	13,9	9,1	13,4
Body depth (%SL)	27,0	19,4	22,7
Body width (%SL)	18,5	11,9	14,2
Caudal peduncle length (%SL)	25,0	17,4	19,5
Caudal peduncle depth (%SL)	11,6	8,5	10,0
Anterior barbel length (%OD)	133,3	8,7	75,8
Posterior barbel length (%OD)	157,1	41,7	107,8
Pectoral–pelvic length (%SL)	27,2	18,8	23,3
Pelvic–anal length (%SL)	24,1	15,0	18,7
Pharyngeal bones L/W (N = 18)	5,5	4,0	4,6
Length of intestine (%SL) (N = 72)	124,3	43,3	89,1

Meristics	
Dorsal fin rays	iii–iv (iv) + 6–8 (7)
Anal fin rays	iii–iv (iii) + 5–7 (6)
Pectoral fin rays	11–15 (13–14)
Pelvic fin rays	7–9 (8)
Total vertebrae	36–39 (37–38)
Precaudal vertebrae	17–20 (19)
Caudal vertebrae	17–20 (18–19)
Predorsal vertebrae	12–14 (13)
Preanal vertebrae	20–22 (21)
Supraneurals	5–9 (7)
Lateral line scales	34–39 (37)
Caudal peduncle scale rows	12–17 (14–16)
Scale rows lat. line–dorsal	5–7 (6)

Meristics	
Scale rows lat. line–pelvic	3–4 (3)
Scale rows lat. line–anal	3–5 (4)
Predorsal scale rows	14–21 (17–18)
Primary scale radii ($\overline{M}$ to nearest whole no.)	9
Pharyngeal teeth (mode)	2, 3, 5–5, 3, 2

Breeding adults of both sexes (but especially the males) have numerous small, white, pimple-like excrescent tubercles scattered over the dorsal surface of the head and predorsal scales. Single rows of similar excrescent tubercles overlie the rays of the paired fins.

In life the colour is pale olive green or brownish-yellow with cream or off-white ventral parts. The iris is silvery-gold and the opercula metallic silvery-gold. The fin rays are dark and the fin membranes hyaline distally with scarlet basal portions (usually the caudal fin has only a salmon tinge). A broad dark band passes mid-laterally from behind the head to the posterior end of the caudal peduncle. Irregular dark blotches are scattered over the dorsal body surface. A short strip of dark pigment occurs along the body adjacent to the base of the anal fin. In breeding dress the males are more intensely pigmented and the dark lateral band is prominent.

The lateral line is usually complete and passes more-or-less straight mid-laterally from the head to the base of the caudal fin. The cephalic lateral line system includes a typically complete cyprinid pattern without disjunctions. The pre-opercular canal passes through a supra-preopercular tube on the opercle bone to join the post-ocular commissure.

Distribution

B. calidus is endemic to the Clanwilliam Olifants River system and is restricted to upper reaches of tributaries within the Cape Fold Mountain ranges (Fig. 44). The species is no longer found in the mainstream of the Olifants River itself although certain early records were taken there.

Notes on breeding biology

The author has observed the spawning activity of this species on two occasions. On January 6, 1981 a school of predominantly (at least 90%) male *B. calidus* were seen swimming over a vertical rock face about one meter below the water surface in a large, deep pool (40–50 m long by 10–20 m wide and three to four m deep) of the Ratels River. The specimens were all ripe and running adults and one female caught with the males was partly spent. The second sighting was a similar school of milling male specimens also against a vertical rock face in a small pool of the Rondegat River. Of 27 specimens collected from this school 25 were ripe running males, one was a ripe female, and one was an active but not fully ripe male. All the ripe running specimens collected had well developed tubercles.

Conservation status

The Clanwilliam redfin is a rare fish species (Skelton, 1977 and 1987). The known populations of this species are all isolated and restricted to short stretches of tributaries beyond the reach of smallmouth and largemouth black bass (*Micropterus dolomieu* and *M. salmoides*), introduced predators.

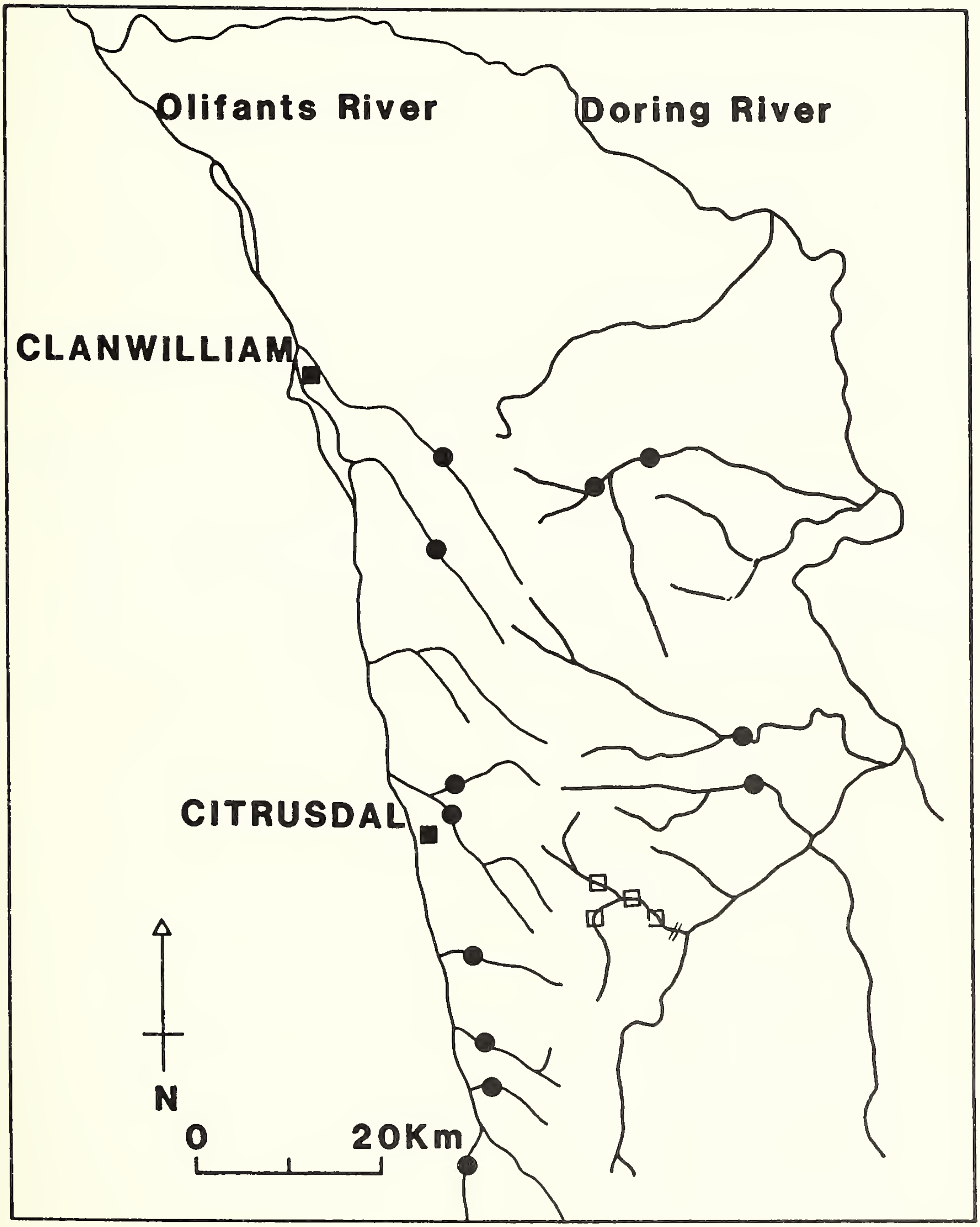

Fig. 45. Distribution of *Barbus calidus* (shaded circles) and *B. erubescens* (unshaded square) in the Olifants River system, based on museum records referred to in this study. Symbols may refer to multiple collection records.

Etymology

The name *calidus*, derived from the latin calidum, meaning hot or a hot drink, refers to the "brightness of the red patches, and the heat of the Olifants River valley in summer time" (Barnard, 1943: 179).

Barbus erubescens Skelton 1974.

Fig. 46.

Synonymy

Barbus calidus (non Barnard): Jubb 1967, 95–97 (in part, the specimens from the population stated as having been discovered by K. J. van Rensburg).

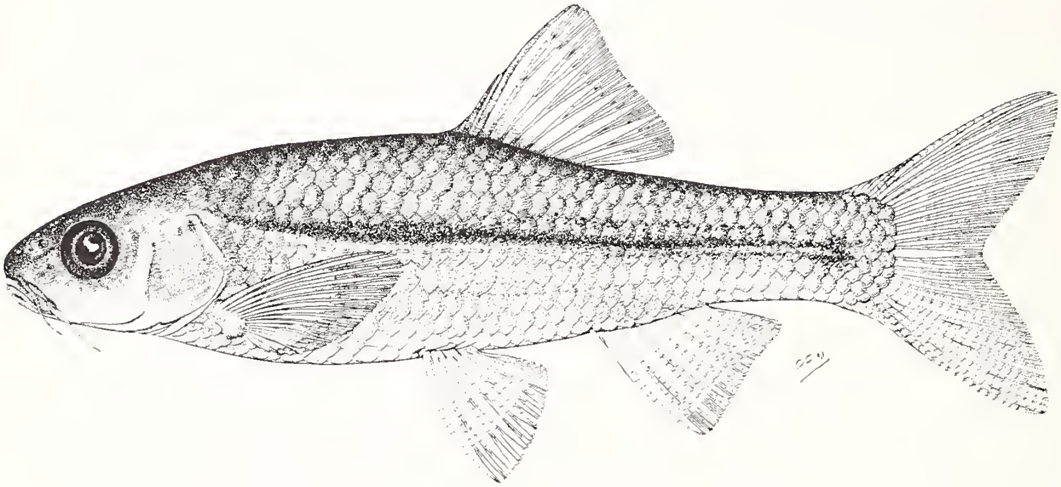

Fig. 46. *Barbus erubescens* Skelton 1974, AMG/P 2043, male, 66 mm SL. Drawn by P. Meakin.

Barbus erubescens Skelton 1974 b, 1–12, Figs 1, 2, 3. Type locality: "Suurvlei River, Olifants River system, western Cape Province, South Africa, 32° 38′ 56″ S., 19° 12′ 21″ E.

Material examined

Holotype: AMG/P 2424, male, 84 mm SL, Suurvlei River, Olifants River system, P. H. Skelton and A. Coetzer, 8 December 1973.

Paratypes: 39 males collected with the holotype: AMG/P 2425 (21); RUSI 74–268 (6); BMNH 1974.6.13, 1–6 (6); MRAC 192175–192180 (6);

5 juveniles, Twee River, P. H. Skelton, 10 October 1973; AMG/P 2426 (2); RUSI 74–266; BMNH 1974.6.13 :9 (1); MRAC 192171 (1).

5 juveniles, Twee River, P. H. Skelton, 6 October 1973: AMG/P 2427 (2); RUSI 74–265; BMNH 1974.6.13:10 (1); MRAC 192172 (1).

5 females, Twee River, P. H. Skelton, 11 October 1973: AMG/P 2428 (2); RUSI 74–267 (1); BMNH 1974.6.13:8 (1); MRAC 192173 (1).

5 females, Middeldeur River, P. H. Skelton and A. Coetzer, 8 December 1973: AMG/P 2429 (2); RUSI 74–269 (1); BMNH 1974.6.13:7 (1); MRAC 192174 (1).

Other material: (all Olifants River system): AMG/P 1388, Twee R, F. L. Farquharson, April 1967; AMG/P 1799, Middeldeur R, P. H. Skelton, September 1972; AMG/P 1866, Middeldeur R, P. H. Skelton, February 1973; AMG/P 1867, Twee R, P. H. Skelton, February 1973; AMG/P 1881, Middeldeur R, D. Heard, November 1972; AMG/P 1882, Middeldeur R, K. J. van Rensburg, March 1964; AMG/P 2043–2049 and AMG/P 3710, Twee R, P. H. Skelton, October 1973; AMG/P 7348, Middeldeur R, I. G. Gaigher, November 1977; AMG/P 7442, Twee R, P. H. Skelton, October 1973.

Diagnosis

B. erubescens differs from all other *Barbus* species in having seven branched rays in the anal fin. It is closest to *B. calidus* from which it differs in the form of the last unbranched dorsal fin ray (flexible and weakly serrated *vs* bony and strongly serrated), the modal number of branched dorsal fin rays (eight *vs* seven) the modal number of predorsal vertebrae (12 *vs* 13), the number and shape of the pharyngeal teeth (2, 3, 4–4, 3, 2 *vs* 2, 3, 5–5, 3, 2), and in the pigmentation and the breeding colouration of males and females.

Description

Morphometrics and meristics are given in Table 22. *B. erubescens* is a fusiform minnow which reaches at least 95 mm SL. The head is longer than the body depth. The mouth is slightly sub-terminal in position, U-shaped and protrusible. The lips are thin and there are two pairs of well-developed barbels that are longer than the orbit diameter in adult fishes. The eyes are lateral to dorso-lateral in position.

TABLE 22.

Morphometric and meristic measurements of *B. erubescens* (N=110)

Measurement	*Range*		
	Max.	Min.	$\overline{M}$
Standard length (mm)	95,0	30,5	64,6
Head length (%SL)	31,2	25,6	27,8
Head depth (%HL)	78,6	62,1	69,2
Snout length (%HL)	36,2	26,4	33,3
Orbit diameter (%HL)	32,4	22,2	26,7
Postorbit length (%HL)	50,0	40,8	46,0
Interorbit length (%HL)	37,9	24,6	31,9
Predorsal length (%SL)	55,7	50,3	53,1
Postdorsal length (%SL)	49,7	44,3	46,9
Dorsal fin base (%SL)	15,7	12,1	13,8
Dorsal fin length (%SL)	24,0	18,9	21,0
Pectoral fin length (%SL)	22,7	18,3	20,6
Pelvic fin length (%SL)	19,3	15,6	17,5
Anal fin length (%SL)	21,7	15,7	18,1
Anal fin base (%SL)	13,9	9,8	11,9

Measurement		*Range*		
		Max.	Min.	$\overline{M}$
Body depth (%SL)		26,5	20,2	23,6
Body width (%SL)		18,3	12,0	15,5
Caudal peduncle length (%SL)		23,4	18,6	21,1
Caudal peduncle depth (%SL)		12,8	10,3	11,7
Anterior barbel length (%OD)		122,2	35,7	96,9
Posterior barbel length (%OD)		150,0	42,9	110,9
Pectoral–pelvic length (%SL)		26,5	10,0	23,5
Pelvic–anal length (%SL)		21,2	15,2	18,2
Pharyngeal bones L/W	(N = 21)	5,7	4,4	4,9
Length of intestine (%SL)	(N = 58)	102,3	57,6	80,8

Meristics	
Dorsal fin rays	iii–iv (iv) + 7–8 (8)
Anal fin ray.	ii–iv (iii) + 6–8 (7)
Pectoral fin rays	11–16 (14–15)
Pelvic fin rays	7–8 (8)
Total vertebrae	36–39 (37–38)
Precaudal vertebrae	18–20 (19)
Caudal vertebrae	17–20 (18–19)
Predorsal vertebrae	11–13 (12)
Preanal vertebrae	20–22 (21)
Supraneurals	6–8 (7)
Lateral line scales	35–40 (37–38)
Caudal peduncle scale rows	15–19 (16)
Scale rows lat. line–dorsal	5–9 (6)
Scale rows lat. line–pelvic	3–5 (4)
Scale rows lat. line–anal	3–5 (4)
Predorsal scale rows	14–21 (15–17)
Primary scale radii ($\overline{M}$ to nearest whole no.)	13
Pharyngeal teeth (mode)	2, 3, 4–4, 3, 2

The body is completely covered with cycloid scales that are only moderately reduced in size anteriorly between the pectoral fins. A small triangular pelvic axil scale is present. Scales are radiately striated with about 13 striae from an anteriorly displaced focus.

The dorsal fin originates over or just behind the origin of the pelvics. The last unbranched dorsal fin ray is segmented and flexible with vestigial serrations evident in some specimens. The posterior margin of this fin is straight or slightly concave. Pectoral fins are rounded, almost reaching the base of the pelvics. The pelvics are also rounded but do not reach the anterior base of the anal fin. The anal fin has a straight or slightly concave posterior margin. The caudal fin is forked with rounded lobes.

There are 2–3 + 6–9 short well spaced gill rakers on the anterior gill arch. The pharyngeal bones are falcate with a length to width ratio of 4,4–5,7. The pharyngeal teeth are in three rows, 2, 3, 4–4, 3, 2. The crowns are pointed in a conical cusp. The intestine is short, less than the SL, and has a single simple flexure.

Adults in breeding condition have numerous minute erupted tubercles (excresences) scattered densely and irregularly over the top and latero-dorsal surfaces of the head, over the exposed surface of the dorsal and latero-dorsal scales and in widely spaced single rows over the fin rays of all fins.

The general colour is pale brown to olive green with lighter ventral surfaces. The head is greenish brown with metallic silvery-gold on the opercula. The iris is silvery-gold and the pupil black. The barbels are dark and conspicuous. The fins are clear or hyaline with scarlet red basal portions (not always well expressed). Fin rays of the dorsal and caudal fins are brown. A more-or-less conspicuous unbroken dark lateral band runs from behind the head to the base of the caudal fin. In breeding condition both sexes (especially the males) become suffused with bright red.

The lateral line is complete and runs straight or follows a slightly curved path from the head to the end of the caudal peduncle. The cephalic lateral line system is complete without reductions or disjunctions. There is a short supra-preopercular tube on the opercle.

Distribution

This species is endemic to the Twee River and parts of its feeder tributaries, the Middeldeur and the Suurvlei Rivers (Fig. 45) (Skelton, 1974). There are a series of waterfalls on the Twee River and *B. erubescens* is not found below the first of these above the confluence of the Twee and the Leeu (Lion) River.

Notes on the breeding biology

The author has observed the spawning activities of this species on two occasions. On December 8, 1973 a large school of ripe running male specimens was netted from the open waters of a large pool of the Suurvlei River. The day was overcast and cool and it was raining intermittently. The second occasion was on October 14, 1983 below a small low level bridge on the Suurvlei River. A school of predominantly (at least 80%) male specimens was milling over the gravel next to a large rock in flowing water below a small cascade. Individual large females would join the milling school and were immediately closely attended by two or three males swimming up from below and behind and contacting the female in the vent region. Specimens of both sexes caught from the school were in ripe running condition. The weather on this occasion was sunny but a cold wind was blowing.

Conservation status

The Twee River redfin is a vulnerable species (Skelton, 1987) because of its very restricted distribution and deteriorating environment.

Etymology

The name *erubescens* refers to the red breeding colours of this species (Skelton, 1974).

DISCUSSION

The taxonomy of African freshwater fishes has, for the main part, entered a secondary phase of revision and consolidation of the primary or alpha phase of purely descriptive accounts. This present study of the redfin minnows is the third taxonomic revision of the group. It differs from the previous two (by Barnard (1938 and 1943) and Jubb (1965 and 1967)) by an analysis which concentrates on characters rather than on the species. This was necessary because the outstanding problems from the earlier revisions were those that required an understanding of the intra- and infra-specific variation of certain characters.

The taxonomic changes made by the study include the recognition and description of a new species *B. erubescens*, the resolution of interspecific boundaries between two species pairs (*P. burchelli* and *P. burgi*, and *P. afer* and *P. asper*), and the recognition of relationship between *P. quathlambae* and the Cape Fold redfin species. It is probably in regard to the last of the abovementioned changes that the approach taken was most valuable i.e. the resolution of phylogenetic relationships of the species. Indeed the resolution of the outstanding taxonomic problems of the species was necessary before, and in turn allows for, the phylogenetic and zoogeographical investigations.

The results of the redfin study may be useful for comparison with other cyprinid groups in Africa. Redfin variability is possibly higher than most other African small *Barbus*-like cyprinid species. For example, many African small *Barbus* species have much more narrow ranges of scale counts (*vide* Greenwood (1962), Jubb (1967), Hopson (1965), Leveque (1985) etc.). This may relate to two factors considered by Nikolsky (1976), firstly that fishes at higher latitudes have in general a greater range of variability, and secondly, character variability in fishes is inversely proportional to the diversity of the fauna. For the redfins, higher latitude and lower faunal diversity are both in favour of greater variability of characters relative to other African minnows.

By concentrating on characters the study also allows a better appreciation of the distinctive features of the species and the groups. This is important for an understanding of the evolution of these minnows, about which little is known or has been written. Evolutionary aspects of the redfins will be discussed in relation to their phylogeny (Skelton, in prep. a).

The present study was instituted partly because of a conservation concern for the species. The conservation status of each species has been noted in the individual species accounts. A high proportion of the species are threatened to a varying extent; three *Pseudobarbus* species are endangered and two others are rare, *B. erubescens* is vulnerable and *B. calidus* is rare. The full reasons for the status of each species is given by Skelton (1987). One of the prime causes for the decline of the redfins is the introduction of alien predator fishes (Skelton, 1986).

Why has there been such a large impact on these particular fishes? The answer is not simple and many factors appear to be involved including the nature of the environment, the life history style of both prey and predator and Man-made changes to the environment. It is hoped that by clarifying the taxonomy of the species this study will assist the important process of the conservation of these attractive and interesting fishes.

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